INSTRUMENT SHOP

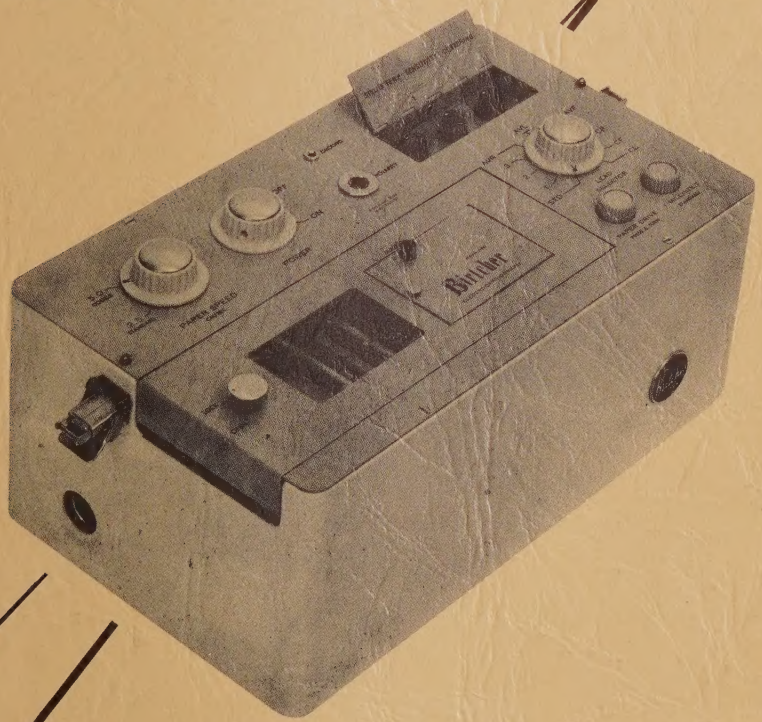
Birtcher

MODELS 300 and 300R

KS9738

SERIAL AK58A-1297B

ELECTROCARDIOGRAPH



SERVICE HANDBOOK
PARTS CATALOG

THE BIRTCHER CORPORATION • LOS ANGELES 32, CALIFORNIA

TABLE OF CONTENTS

PART 1 MODEL 300

Section		Page
I	GENERAL DESCRIPTION	1
	1-1. Introduction	1
	1-2. Purpose of Equipment	1
	1-3. Construction	1
	1-5. Equipment Supplied	1
	1-6. Summary	1
II	GENERAL THEORY	3
	2-1. Amplifier Input Circuit	3
	2-2. Input Amplifier	3
	2-4. Second Amplifier	3
	2-5. Sensitivity Control	4
	2-6. Driver Stage	5
	2-7. Output Amplifier	5
	2-8. Standardization Circuit	5
	2-9. Paper Drive Control	5
	2-10. Automatic Blanking	6
	2-11. A-C Interference	6
	2-12. Power Supply	6
III	MAINTENANCE	8
	3-1. General	8
	3-2. Complete Alignment Procedure	9
	3-3. Removal of ECG from Case	9
	3-4. Power Supply Adjustments	9
	3-5. Sensitivity and Centering Check	9
	3-6. Standardizing Adjustment	9
	3-7. Frequency Response Adjustment	9
	3-8. In-Phase Rejection Capability	10
	3-9. Paper Guide Bar Adjustment	10
	3-10. Stylus Pressure Adjustment	11
	3-11. Paper Tension Adjustment	12
	3-12. Performance Checks	12
	3-14. Resistance Measurements	12
	3-15. Voltage Measurements	12
	3-16. Test Recording	12
	3-17. Maintenance Procedures	12
	3-18. Maintenance of Stylii	12
	3-19. Replacement of Stylii	16
	3-20. Replacement of Indicator Lamps	16
	3-21. Replacement of Galvanometer	17
	3-22. Power Transformer Replacement	17
	3-23. Tube Replacement	17
	3-24. Replacement of Zener Diode	17
	3-25. Lubrication	17
	3-26. Testing Patient Cable	17
	3-27. Voltage and Resistance Measurements	17
IV	PARTS LIST	18
	Figure 14. Major Assembly	19
	Figure 15. Accessory List	20
	Figure 16. Control Panel Assembly	21
	Figure 17. Chart Door Assembly	22
	Figure 18. Chassis Assembly	23
	Figure 19. Chassis Assembly, Left Side View	25
	Figure 20. Chassis Assembly, Right Side View	26
	Figure 21. Chassis Assembly, Bottom View	27
	Figure 22. Chassis Assembly, Rear View	29
	Figure 23. Schematic Diagram	31
V	ADDENDUM	32

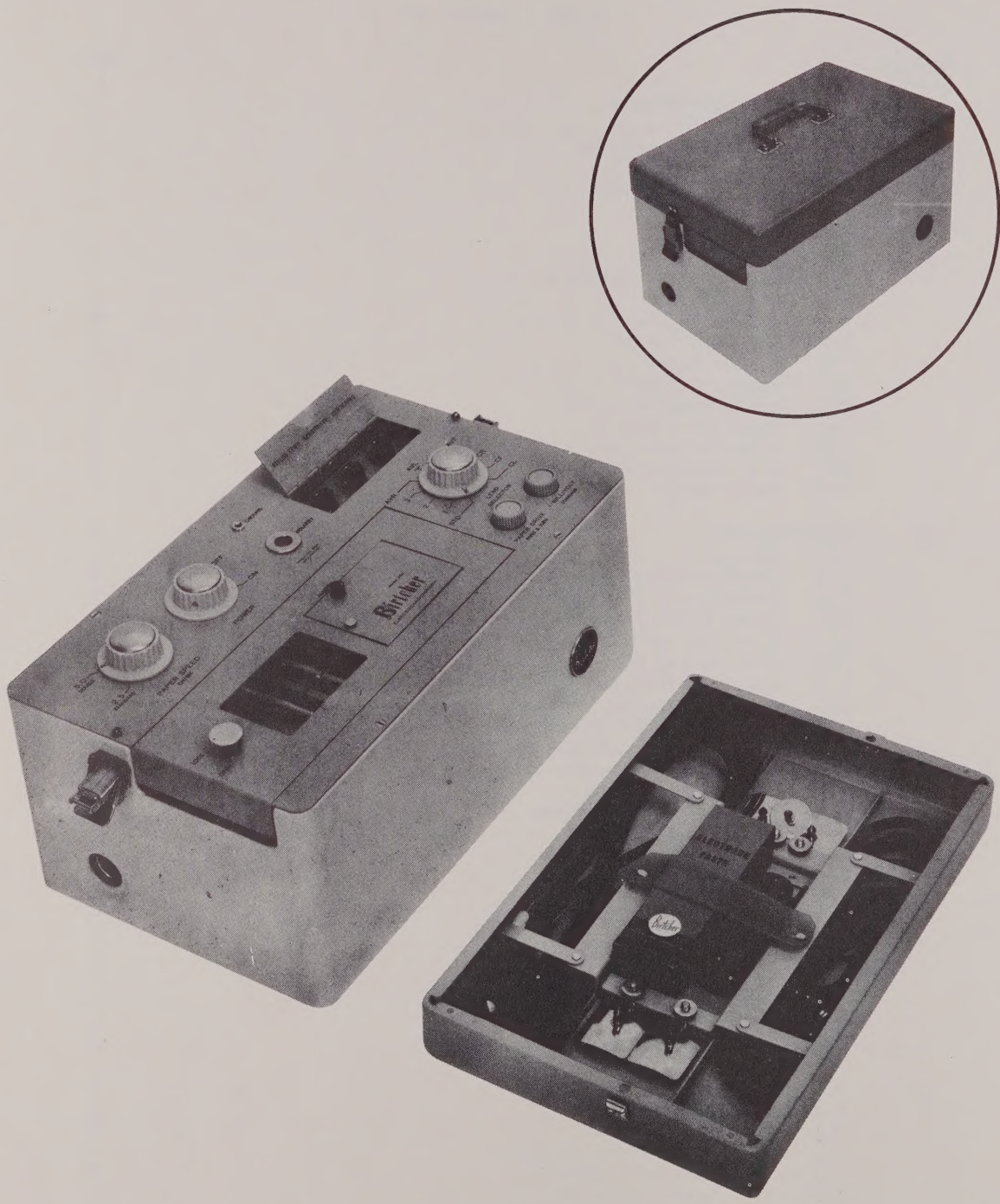


Figure 1.

Birtcher Electrocardiograph, Model 300

SECTION I
GENERAL DESCRIPTION

1-1. INTRODUCTION. This manual comprises complete service instructions for the Birtcher Model 300 Electrocardiograph, which is shown in figure 1.

1-2. PURPOSE OF EQUIPMENT. The purpose of the Birtcher Model 300 ECG is to graphically record the electrical impulses associated with the action of the human heart, thereby providing the cardiologist with a permanent electrocardiogram for immediate analysis or for future reference. The cardiac potentials are recorded on a roll of heat-sensitive, rectangular graph paper (see figure 2) and appear as waveforms similar to those produced by an oscilloscope. Every effort has been made in the design of this instrument to record these waveforms with a high degree of accuracy and without introducing distortion. In addition, special circuitry has been incorporated to reject interference from external sources and to stabilize the operation of circuits that are necessarily critical due to the sensitivity of the instrument.

1-3. CONSTRUCTION. The Birtcher Model 300 Electrocardiograph is a compact, ruggedized instrument, designed for fixed or portable operation. The entire chassis and cabinet are manufactured of spot-welded light weight sheet aluminum. The cabinet and panel and lid are finished in two-tone baked enamel and are soil and stain resistant. All operating controls are mounted on the top panel and are easily accessible, since the panel faces upward when the ECG is in its normal operating position. When the instrument is stored or is being transported, the controls are protected by a lid, which is secured by means of trunk-type fasteners. A handle attached to the lid facilitates portability of the ECG. A plastic cover is supplied as an accessory to protect the instrument during periods when it is not in use or for protection during transportation on outside calls. Since the Birtcher Electrocardiograph does not contain any components that are easily damaged by temperature extremes, no unusual precautions need to be taken to protect the instrument in this respect when transporting it.

1-4. Latest techniques for construction of electronic equipment have been utilized in building the Birtcher Model 300 Electrocardiograph. Weight and bulk have been reduced wherever possible without sacrificing quality, performance or dependability. In keeping with this, transistors have been employed in several instances in place of vacuum tubes, and printed circuitry has been utilized for two major assemblies. One printed circuit board is employed to mount all components of the amplifier assembly. Another board, mounts all components of a regulated power supply, with the exception of larger items, such as the power transformer and rectifiers. The amplifier assembly is shock-mounted to eliminate trace instability due to external vibration or jarring.

1-5. EQUIPMENT SUPPLIED. The accessories supplied with the Birtcher Model 300 Electrocardiograph are shown in Section IV, figure 15.

1-6. SUMMARY. Technical data for the Birtcher Model 300 Electrocardiograph is summarized as follows:

TECHNICAL DATA SUMMARY

Finish:	Two-tone, infrared-cured, baked enamel
Dimensions:	16-1/4 x 9-3/4 x 9-1/2 inches high with lid Volume: 1505 cu. in.
Weight:	29 pounds with all accessories
Input Power Requirement:	115 volts, 60 cps (Note: upon request 50 or 60-cps models can be supplied to operate at 115, 150, 220 or 250 volts.

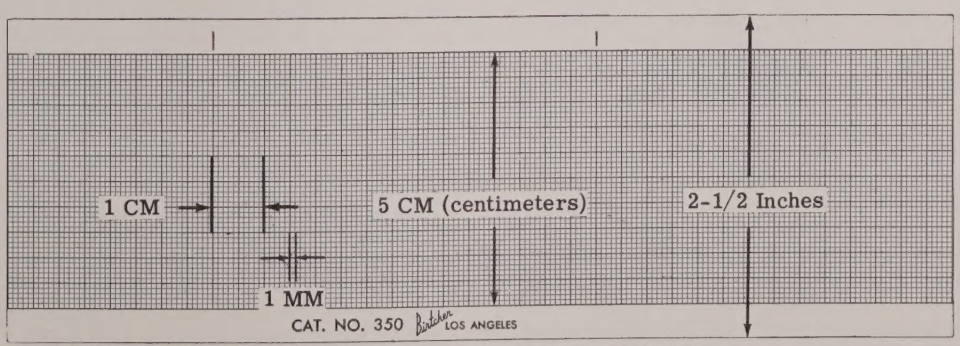


Figure 2. Birtcher No. 350 Chart Paper

TECHNICAL DATA SUMMARY (Continued)

Power Consumption:	90 watts max
Grounding:	To ground side of power line through line cord or by means of a special ground lead.
Patient Circuit:	Input resistance 10 megohms each grid, differential input
Amplification:	Four stages of push-pull with progressive differential effect
Interference Rejection:	0.02% or better
Standardization Voltage:	1 millivolt dc
Voltage Regulation:	1. Circuit voltages a. Regulation to 0.0029% with ±10% a-c line voltage change b. A-c ripple, 5 millivolts peak-to-peak 2. Heater voltage for input tubes a. Regulation to 0.0096% with ±10% a-c line voltage change b. A-c ripple, 5 millivolts peak-to-peak
Recording Method:	On heat-sensitive paper by heated stylus
Total Sensitivity:	12.5mm/mv minimum with continuous control
Frequency Characteristic:	The recorded response to 1 millivolt peak voltage variation from 1 cycle to 15 cycles per second is greater than 90%, and from 15 to 40 cycles greater than 80%
Zero Position:	Adjustable ±25mm progressively and without lag
Decay Time:	At 0.2 second, response down 5%
Linearity:	Response within ±5% over 4 cms of the paper
Recording Speeds:	2.5 and 5.0 cms per second with changeover permitted during recording
Time Marking:	Automatic and continuous by means of a second stylus and associated synchronous timing motor
Paper Drive:	Synchronous motor
Galvanometer:	a. Sensitivity 6.4 to 7.2 ma for 1 cm deflection at 10 cm radius b. Gauss 8000 c. Restoring force, 140,000-dyne cm
General Operation:	Standard sensitivity of 1 millivolt per cm Lead selector switch with 1, 2, 3, AVR, AVL, AVF, V, CR, CF, and CL positions Automatic blanking between leads except V leads
Vacuum Tube Complement:	2 7025's 2 6CM7's 1 6AU6 1 6AS5 1 5651
Semiconductors:	2 2N292 transistors 1 2N2869 transistor 1 1N1314 Zener diode (specially selected) 1 1N34A crystal diode

SECTION II
GENERAL THEORY

2-1. AMPLIFIER INPUT CIRCUIT. (Refer to schematic diagram, figure 23.) The amplifier input circuit consists of the five-wire patient cable and its associated electrodes and input connectors, LEAD SELECTOR switch (S1), patient terminal network resistors R1 through R7 and input network Z1. LEAD SELECTOR switch S1 is a five-wafer, eleven-position switch that is used to establish the proper patient terminal networks for the various leads. All patient electrodes are connected to the contacts of S1 via receptacle J1, and therefore, as its name implies, the LEAD SELECTOR switch selects the proper electrodes (or combinations thereof) for connection to the grids of input amplifier V1 or to ground, depending upon the lead selected. The Electrocardiogram leads obtainable are illustrated in Section VII of the Birtcher Operation Manual. The cardiac potentials are direct-coupled via 10,000 ohm resistors to the grids. R-f bypass capacitors are employed at the grids to eliminate r-f interference if present. The use of 10 megohm grid resistors assures a high input impedance. Provisions for insertion of a fuse in the patient circuit are incorporated in the Birtcher Electrocardiograph if the user requires such a fuse. However, since the circuitry of the Birtcher ECG is such that the fuse is not necessary for protection of the patient, the equipment is shipped with a shorting element installed in the fuse clip, provided the fuse is not called for in the specification published by the procuring agency. Since the presence of a fuse in the patient circuit introduces a given amount of resistance in this circuit, use of the fuse is not normally recommended, because any a-c voltages, if present, will be developed across this resistance and, of course, be coupled to the input amplifier. The shorting element and fuse clip are shown in figure 3.

2-2. INPUT AMPLIFIER. The input amplifier, V1, consists of a twin triode connected as a differential push-pull amplifier. Perfect balance is assured by employing plate load resistors of 1% tolerance. Plate voltage is obtained from the 260-volt regulated supply. Because the input amplifier is extremely sensitive to minute signal changes, it follows that this stage would be equally sensitive to any existing interference signals if it were not for the precautions taken to prevent their formation and to exclude them if present. Microphonics are minimized by using rubber shock mounts for the entire amplifier assembly. A special regulated d-c voltage supply is used to provide filament voltage for V1 to prevent the inevitable pickup of a-c interference that use of a-c filament voltage entails. In addition, by using a regulated filament supply, stability is ensured despite line voltage variations. The circuit for regulation of filament voltage is described in paragraph 2-13. Voltages slightly lower than normal are used for the filaments of V1 and V2 to reduce grid current and to maintain as high an input impedance as possible.

2-3. As indicated in the schematic, a type 2N292 transistor, Q1, is employed in the cathode circuit of V1. Its purpose is to improve the natural in-phase rejection capability of the push-pull amplifier circuit. (The term in-phase rejection refers to the rejection of undesired interference signals, which are usually fed in via the patient circuit, and which, unlike the signal voltages, appear in phase at the grids of V1 rather than 180° out of phase.) As an aid to understanding how the presence of Q1 influences interference rejection, consider the effect that a large cathode resistor has in this respect. The presence of in-phase signals at the grids causes equivalent and identical changes in plate currents of the two tube sections. Due to the combined effect of the resultant space current, the signal voltage developed across the common cathode resistor is in phase with the grid signal, and therefore opposes and cancels the interference signal through a degenerative effect. Normal signals that are 180° out of phase are not affected, since the signals superimposed on the plate currents of the two tubes oppose each other in the cathode circuit and are cancelled, in a manner characteristic of push-pull amplifiers. From a theoretical standpoint, 100% rejection of in-phase interference signals is possible if the resistance of the cathode resistor could be made larger than the individual resistances of plate load resistors R11 and R12. This high resistance would have a large voltage drop and reduce plate voltage and therefore stage gain. The effect of transistor Q1 and associated resistors R16, R17 and R18 is to produce the desirable effect of a large cathode resistance without its attendant voltage reduction and loss of gain. The proper base bias for Q1 is established by a voltage divider consisting of R17 and R18, which is connected between ground and a regulated -11 volt (nominal) potential. This results in a fixed d-c bias voltage at the cathode of V1. Because of the presence of Q1, the impedance at the cathode of V1 (looking toward the -11 volt line) is high -- effectively 30 or 40 times the resistance of R16. The impedance in the opposite direction, however, is low. Thus, the resistance in the cathode circuit appears to be high insofar as a-c signals are concerned, but low to the space current flowing in the cathode circuit.

2-4. SECOND AMPLIFIER. The amplified signals from the input amplifier, V1, are capacitively coupled by means of capacitors C5 and C6 to the grids of the second amplifier, V2. This amplifier also employs a type 7025 tube with its two triode sections operated in push-pull. While this amplifier is less critical than the input amplifier, insofar as susceptibility to a-c interference is concerned, the precaution of employing regulated d-c voltage for the filaments is still necessary nevertheless. The plate load resistances for the two sections of V2 are comprised of the two resistance sections of CENTERING potentiometer R25 (figure 3). The arm of R25 is connected to the regulated 130-volt

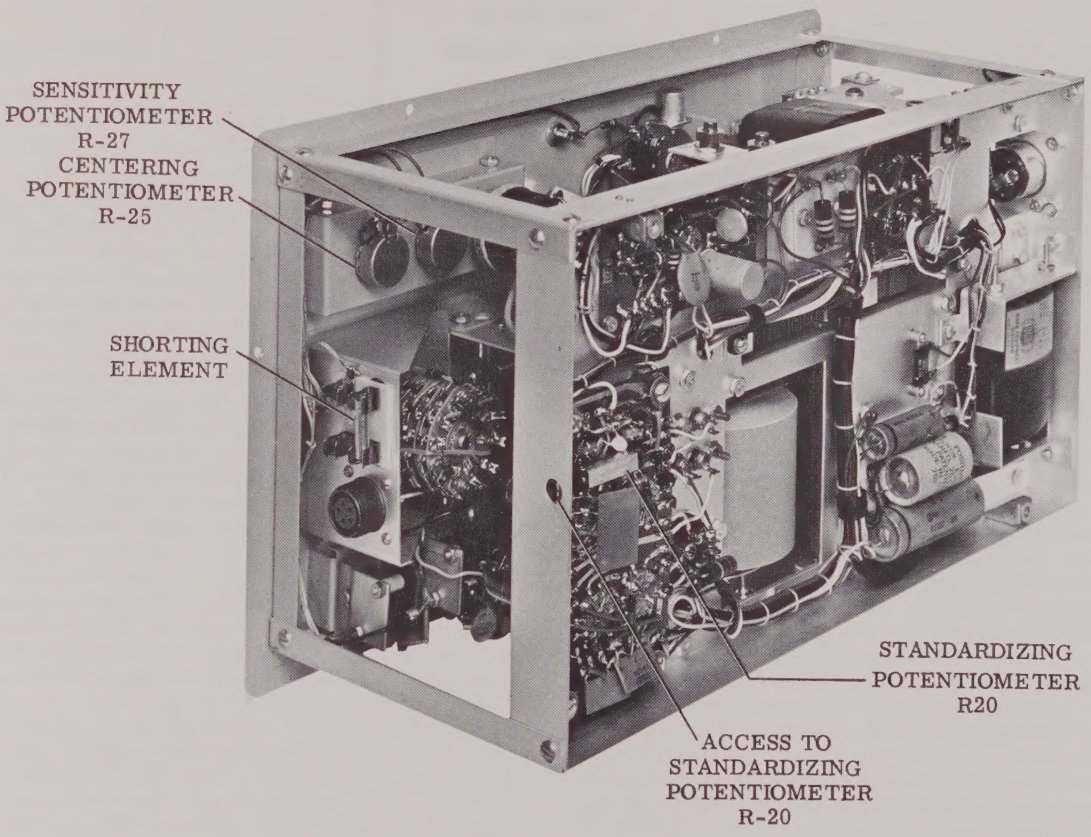


Figure 3

supply. Assuming perfectly balanced tube sections with equal plate current flow in each section, the plate voltages of both tube sections will be equal. These voltages are direct-coupled to the grid circuit of the driver stage via 475K isolating resistors R28 and R29. After further amplification by the driver the voltages are fed to the output stage, which is also a d-c amplifier, and thus these potentials ultimately determine the currents in the two sections of the center-tapped galvanometer coil. If equal voltages are present at the plates of V2, equal currents will flow in the galvanometer coil, and the writing stylus will be centered at the base line on the recording paper. If the arm of R25 is moved toward either plate, the resultant unbalance of the plate load resistances will cause the plate voltages to be at variance. Consequently, unequal d-c voltages will be impressed on the grids of all succeeding direct-coupled push-pull amplifiers. This results in displacement of the writing stylus in either direction, depending upon which way the shaft of CENTERING control R25 is rotated. From the foregoing discussion it is obvious that R25 can also be used to compensate for reasonable conditions of unbalance involving V2, V3 or V4, merely by appropriate displacement of the arm of the potentiometer. Although potentiometer R25 will have a similar effect on the cardiac signal voltages that are developed across it, it is not adjusted during actual recordings, but only as part of the preliminary adjustment and alignment procedure.

2-5. SENSITIVITY CONTROL. Sensitivity of the Birtcher Electrocardiograph is controlled by potentiometer R27. As shown on the schematic diagram, R27 is connected in series with resistor R26. The combined resistance is employed as a high-resistance shunt between the two plates of V2. Consequently, its effect is to cause partial cancellation (and therefore attenuation) of the signal voltages developed across the two resistance sections of potentiometer R25. As a result, maximum signal is fed to the grids of the third amplifier when SENSITIVITY control R27 (figure 3) is adjusted for its maximum 10-megohm resistance (shaft rotated fully clockwise); and minimum signal input results when R27 is adjusted for zero resistance (shaft rotated fully counterclockwise). This enables the operator to adjust the sensitivity of the ECG for the proper stylus deflection when the 1-millivolt standardizing voltage is applied, thereby making compensation for gradual changes in sensitivity, such as those which occur as a result of vacuum tube deterioration.

2-6. DRIVER STAGE. The driver stage employs the "A" sections of two type 6CM7 tubes (V3 and V4) in a push-pull d-c amplifier circuit. Since the signal level at the grid of this amplifier is comparatively high as a result of previous amplification, this stage is less subject to minute a-c interference voltages, and consequently the 6.3-volt a-c supply can be employed to heat the filaments of V3 and V4. The 260-volt regulated plate supply voltage is still used, however, to ensure operational stability. The driver stage is characterized by the presence of positive and negative feedback components in its grid circuit. Negative feedback from plate to grid of each tube section is provided by two 10-megohm resistors, which are part of network Z2. Negative feedback is used to promote stability and to preclude any possible tendency toward oscillation. The use of negative feedback, however, tends to cause an overall reduction of gain. Since the frequency response of the galvanometer falls off beginning at approximately 30 cps, positive feedback is employed to reduce the negative feedback and is designed to have maximum effect at 40 cps. This provides compensation for the natural loss of gain at frequencies above 30 cps. Positive feedback is produced by connecting a 600 uuf capacitor, C12, from the plate circuit of V3 to the junction of the two 10-megohm resistors in the grid circuit of V4. Capacitor C11 performs an identical function for the other half of the push-pull amplifier and is connected similarly. This capacitor, which is designated FREQ. ADJ., is a variable type and can be adjusted over a range of 100 to 780 uuf to compensate for circuit variations and achieve required frequency response. The two 0.001 uuf capacitors shown connected to the grids of the third amplifier are part of the frequency compensating network.

2-7. OUTPUT AMPLIFIER. The output amplifier provides the current to drive the galvanometer. It functions as a cathode follower and utilizes the "B" sections of the two 6CM7's (V3 and V4) in a push-pull arrangement, with the galvanometer connected in the low-impedance cathode circuit. The low impedance output results in an improvement of the electrical damping characteristics of the galvanometer. The plates of the two amplifier sections are tied together; voltage for the plates is obtained from the unregulated 390-volt supply. Since the gain of this stage is less than unity, and since plate voltage variations have an equal effect on the currents in the two sections of the galvanometer coil because of the push-pull arrangement of the coil in the cathode circuit, a regulated plate supply is not required for the output amplifier. The signal is direct-coupled from the plate of the preceding amplifier to the control grids of the output amplifier.

2-8. STANDARDIZATION CIRCUIT. The 1-millivolt reference potential that is used in standardization is developed by rectifying and filtering the output of an r-f oscillator circuit. The oscillator circuit employs a type 2N292 transistor, Q2, in what can be considered a transistorized equivalent of a tuned-plate tuned-grid oscillator. Oscillation occurs at a fixed frequency of approximately 250 kc. Since the frequency of operation is not critical no tuning adjustments are required. Consequently, frequency is established by the resonant frequency of the two tank circuits, consisting of L1 and L2 and the distributed capacities that exist in their respective windings. Since the standardization voltage is not required during any operation other than that of standardizing the ECG, the oscillator is normally inoperative because of the open circuit that exists when the 1 MILLIVOLT STANDARD switch, S4, is not depressed. When this switch is held closed by the operator, oscillation occurs and is fed via capacitor C7 to a type 1N34 crystal rectifier, CR1. Flow of the rectified d-c current through potentiometer R20 (figure 3) and resistor R19 in series causes a potential of exactly 1 millivolt to be developed between the arm of R20 and the junction of R20 and LEAD SELECTOR switch S1. The exact 1-millivolt standardization potential is established by the setting of R20. When S1 is in STD position, this potential is fed via input network Z1 and applied to the grid of input amplifier V1. All other potentials from the patient circuit are excluded by S1 at this time. Filtering of the rectified r-f is accomplished by capacitor C8. Transistor operating voltage is supplied by the regulated d-c filament supply. Since it is standard procedure to enter a standardization pulse at the beginning or at the end of each lead being recorded (or to superimpose one on the flat portion of the waveform while a recording is being made), switch S1 is connected in such a manner that the standardization potential may be applied during the recording of any lead to grid pin 7 of V1 as before, and to grid pin 2 through the patient circuit. Thus, the operator is not required to return the LEAD SELECTOR switch to STD position in order to enter a standardization pulse in any lead.

2-9. PAPER DRIVE CONTROL. Depression of the PAPER DRIVE control (S6) performs three functions:

a. Starts paper drive motor.

b. Unblanks amplifier (see paragraph 2-10).

c. Removes stylii from pre-heat status (see paragraph 2-12).

It is important that the technician making tests remember these points. During normal use, the PAPER DRIVE control may be locked in by a slight turn clockwise after depressing.

2-10. AUTOMATIC BLANKING. Automatic blanking of the amplifier is provided to protect the writing stylus from the violent excursions that result from switching from one lead to another. Blanking is accomplished by the contacts of relay K1. When K1 is energized, its contacts place a short between the control grids of V2, and shorts them to B-minus, thereby cancelling all signal inputs. K1 is normally energized; it is de-energized only when a recording is being made. K1 is energized as follows. Coil terminal 2 is connected through current-limiting resistors R8 and R9 to the unregulated 390-volt supply. Coil terminal 1 is connected via the normally closed contacts of switch S3 to the -11 volt supply. The resultant current flow through the coil causes the relay to energize. At the time a recording is made, the PAPER DRIVE control on the top panel is depressed (see paragraph 2-9). This control actuates switch S3, which causes the contacts of the switch to open. When this occurs, the coil circuit is interrupted and the relay is de-energized;

this causes restoration of normal amplifier operation for the duration of the recording. To protect the galvanometer from sudden variations of signal inputs that occur when switching from one lead to another, as well as from the transient voltages caused by the switching action itself, an automatic blanking switch (S2) is placed in parallel with switch S3. Thus, when either switch is closed, relay K1 will be energized. Switch S2 is mechanically coupled to the LEAD SELECTOR switch in such a manner that it is momentarily actuated whenever a different lead is selected. This causes the coil circuit of K1 to be completed for the instant the switch contacts are closed. During this brief interval, capacitor C4 is charged and relay K1 is energized. K1 remains energized after release of the switch contacts for approximately one second, due to the relatively slow discharge of capacitor C4 through the coil of K1 and resistors R8, R9 and R10. This one-second interval allows the input amplifier sufficient time to become stabilized after application of the new lead potentials.

2-11. A-C INTERFERENCE. A-c interference constitutes the most common form of interference that is encountered in electrocardiography. Obviously this must be attributed to the widespread use of fluorescent lighting systems and other equipment that operates from a 115-volt 60 cycle power source. An example of the effect of this interference is shown in figure 12. The excellent in-phase rejection characteristics of the Birtcher Model 300 Electrocardiograph can cause cancellation of normal amounts of interference, but nevertheless all possible steps must be taken to reduce this interference by eliminating it at its source or operating in an area that is relatively interference-free. In keeping with this, it is essential that the importance of grounding the chassis be recognized, since the chassis is employed in the patient circuit, and any a-c voltages present on it will be applied to the grids of the input amplifier. By inserting the power plug properly the ground side of the line is connected to the chassis via resistor R37, as shown in the schematic diagram. A neon POLARITY indicator on the top panel is used to provide an indication of improper polarization should the power plug be inserted incorrectly. As indicated in the schematic diagram, the neon indicating lamp is connected between the side of the incoming power line that is to be grounded and a chromium plated ring mounted on (but insulated from) the top panel of the ECG. If polarity is incorrect, the lamp will glow when the ring is touched, since an a-c circuit is completed by means of body capacity to ground. If polarity is correct the lamp will not glow. In some instances of severe interference a direct ground to a water pipe or radiator will be required. A ground cord (figure 15) is supplied for this purpose, one end of which plugs into the ground jack on the top of the panel (figure 10).

2-12. POWER SUPPLY. The power supply develops all voltages required for operation of the ECG. These include a-c filament voltage, regulated d-c filament voltage, a-c stylus voltage, regulated bias voltage, regulated B-plus voltage, and unregulated B-plus voltage. The a-c filament voltage is provided by the 6.3-volt winding of power transformer T1 (figure 4). Voltage of approximately 2.2 volts is supplied by another winding to the stylii heating circuit. As shown in the schematic, resistor R40 is permanently connected as a current-limiting resistor in this circuit. Its function is to maintain the stylii at a temperature that will not cause any operating delay for warm-up purposes, but below the level that might cause rapid deterioration of the stylii through oxidation brought on by the effects of prolonged operation at excessive temperatures. When the PAPER DRIVE control is depressed (see paragraph 2-9), it actuates switch S7, which causes STYLUS TEMP. potentiometer R39 (figure 4) to be placed in parallel with R40. This causes an increase in stylii current and therefore an increase in stylii temperature as well. By varying the position of the tap on R39 the overall resistance of the circuit is varied, and consequently, the stylus temperature can be adjusted to the proper level for recording by this means.

2-13. Regulated d-c filament voltage is developed for amplifier tubes V1 and V2 by rectifying and filtering the output of the 25-volt winding of T1 and by the use of a transistor for voltage regulation purposes. Full-wave rectifier CR2 and capacitor C14 provide the above functions in association with a type 2N2869 transistor Q3. Base bias voltage on Q3 is supplied by the -11 volt regulated output of the power supply, as indicated on the schematic. By maintaining a constant base bias voltage on Q3, collector to emitter current remains constant despite changes in line voltage. Thus the emitter voltage remains at a constant amplitude and is the same potential as the base voltage, less the voltage drop between the base and the emitter.

2-14. Unregulated B-plus voltage of approximately 390-volts is developed by the high voltage winding of transformer T1 working into a full-wave rectifier circuit. Transformer T1 develops 365-volts each side of center tap which is applied to rectifiers CR3 and CR4. The output voltage is filtered by capacitor C16 and the resultant 390 volts constitutes the unregulated B-plus supply, which is available between terminals 5 and 12 on the power supply printed circuit board.

2-15. The regulated 260-volt and -11 volt supply voltages are developed by a voltage regulator consisting of a control tube, V6, a series regulator tube, V5, a voltage regulator tube, V7, a Zener diode, CR5, and associated circuitry. The parallel-connected combination of CR5 and resistors R47 through R51 is connected in series with regulator tube V5 and a shunt resistor R44. The above combination functions in a manner similar to a voltage divider that contains a variable resistor, the value of which changes in accordance with the variations of the voltage impressed across the divider network. If the value of the variable resistor increases or decreases in proportion to an increase or decrease in the amplitude of the applied voltage, the voltage at the various taps will remain at a constant level despite fluctuations of this voltage. In the preceding network V5 functions as the variable resistor; and since its internal impedance is essentially a function of its grid voltage, by causing the grid voltage to vary in accordance with changes of the d-c voltage that is to be regulated, automatic regulation of the voltages in the voltage divider network is possible. Control of V5 is accomplished by V6. The grid of the latter is connected to the arm of potentiometer R48 (260 ADJ.) (figure 4). If the line voltage should increase for example, the amplitude of the unregulated B-plus increases and this

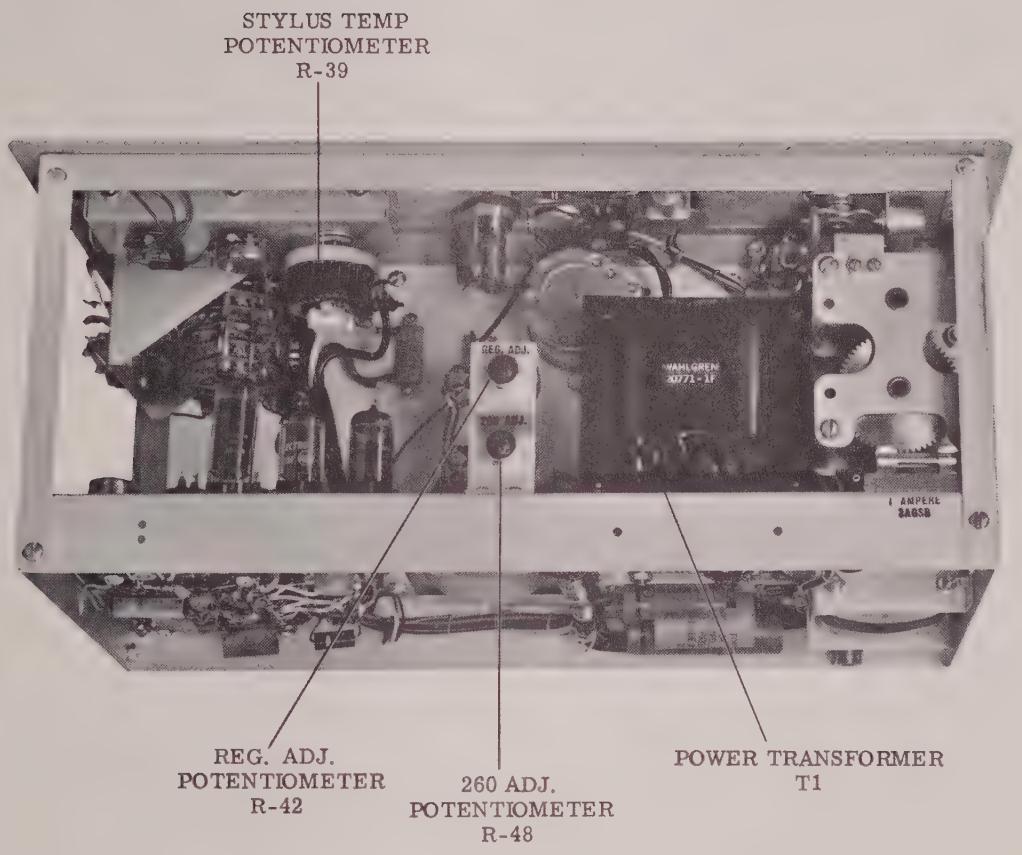


Figure 4

tends to cause an increase in the voltage applied to the screen grid of V6. This causes an increase in V6 plate current and a resultant decrease in plate voltage due to the voltage drop across plate load resistor R45. The grid of V5 is tied to the plate of V6, and consequently the plate current of V5 is reduced and the internal plate-to-cathode resistance of the tube increases. The increase is sufficient to counteract the effect of the increase in amplitude of the B-plus voltage, and thus any change in amplitude of the regulated voltages is counteracted. When line voltage drops, the action of the voltage regulator is similar but opposite, with a decrease in V6 plate current and a resultant increase in V5 plate current. When this occurs, the internal resistance of V5 decreases and the regulated voltages remain at their proper levels. Resistor R44 provides an alternate path for the load current during initial warm-up of the equipment. Because of the alternate current path through R44, sufficient negative voltage is developed to operate the regulated d-c filament voltage supply, despite the higher circuit resistance that exists before V5 reaches full conduction. Voltage regulator V7 is a constant-voltage device that places a reference voltage of approximately 87 volts on the cathode of V6. Since this voltage is constant, V6 can only be affected by changes of grid or screen potentials.

2-16. The screen grid potential of V6 can be changed either by variations in the unregulated B-plus voltage (in which case the changes are immediately counteracted and grid potentials restored to normal) or by changing the setting of 260 ADJ. potentiometer R48. Moving the arm of R42 in either direction causes the grid potential of V6 to change, and since this in turn causes an increase or decrease in the plate-to-cathode resistance of V5, depending on the direction of movement, the 260-volt regulated voltage can be adjusted to the proper value. This adjustment is made only as part of the initial alignment and adjustment procedures. Capacitor C18 is incorporated to minimize ripple content of the regulated voltage. The screen voltage of control tube V5 can be adjusted by means of REG. ADJ. potentiometer R42 (figure 4), which is part of a bleeder network across the unregulated B-plus voltage. This adjustment places the voltage regulator at the center of its operating range. For example, with a primary input of 115 volts a-c, and with R42 properly set, the voltage regulator would be effective over a 105 to 125-volt primary voltage range. Other ranges can be established by changing the setting of R42 if local primary power is not within ±5% of 115 volts. R42, when properly adjusted, also minimizes ripple in the regulated B-plus output voltage. Zener diode CR5 is employed

to provide the regulated -11 volt (nominal) supply at terminal 5 of the power supply. This voltage is maintained within the limits of -10.8 to -11.9 volts as a result of employing specially-selected type 1N1314 diodes. CR5 is a constant-voltage device; in application it is similar to voltage regulator tube V7. The -11 volt potential is particularly critical because it constitutes B-minus, and therefore, the cathodes of all amplifiers are returned to terminal 5. This voltage is critical in another respect, also, inasmuch as it is used as the base bias voltage for Q3. As a result the stability of the regulated d-c filament supply depends on the stability of the -11 volt potential.

SECTION III
MAINTENANCE

3-1. GENERAL. In the course of normal operation the Birtcher Model 300 Electrocardiograph requires certain routine maintenance of the type that can be performed by operating personnel who are thoroughly familiar with the operating characteristics of the instrument but who may not understand all of its technical aspects. Maintenance of this type includes the following:

a. Replacement of indicator lamps.

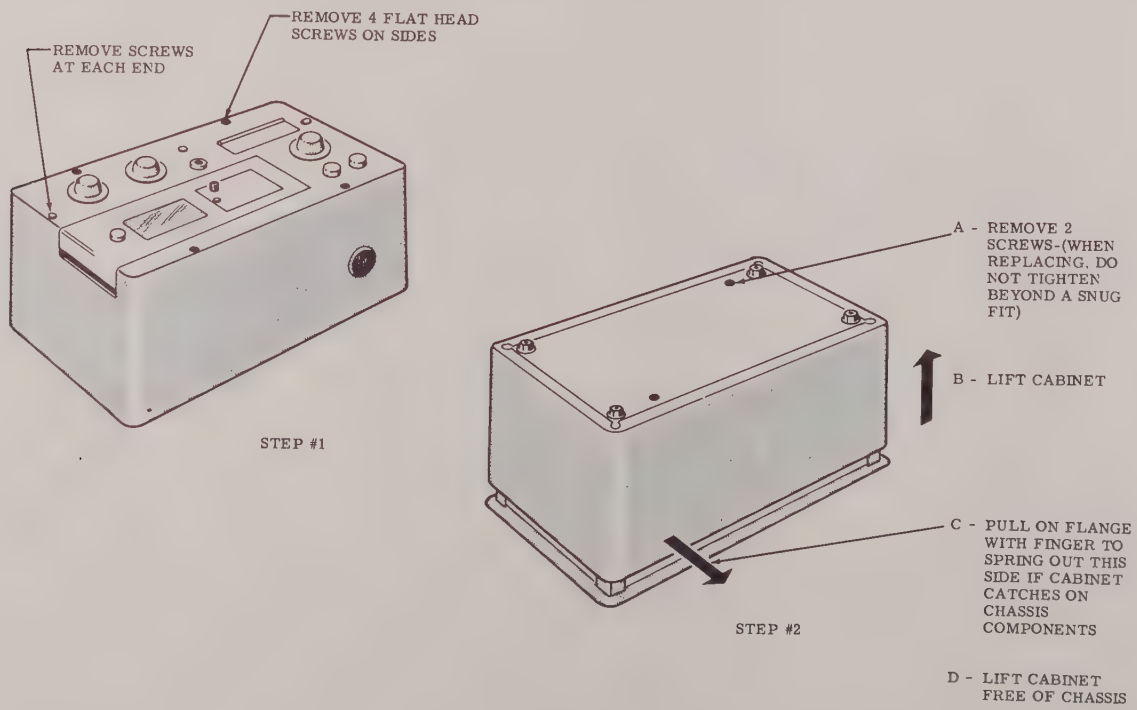
b. Replacement of power fuse.

c. Repair or replacement of writing or marking stylii; adjustment of stylus pressure.

d. Replacement of recording paper and adjustment of paper tension and paper guide bar.

e. Cleaning of electrodes.

Operating personnel, therefore, should know how to perform the above maintenance, and should also be able to recognize the symptoms that indicate that it is required. The following maintenance should be performed by competent factory-recognized technicians who have a thorough understanding of the equipment. Since most symptoms of trouble are clearly indicated by deviations from the characteristics exhibited by normal recordings, it is essential that both operating and maintenance personnel be well-acquainted with these characteristics in order to recognize possible equipment malfunctions. Before taking any corrective action, however, make certain that the trouble is in the equipment, and is not caused by such things as improper


REMOVE 4 FLAT HEAD SCREWS ON SIDES
REMOVE SCREWS AT EACH END
STEP #1
A - REMOVE 2 SCREWS-(WHEN REPLACING, DO NOT TIGHTEN BEYOND A SNUG FIT)
B - LIFT CABINET
C - PULL ON FLANGE WITH FINGER TO SPRING OUT THIS SIDE IF CABINET CATCHES ON CHASSIS COMPONENTS
STEP #2
D - LIFT CABINET FREE OF CHASSIS

CABINET REMOVAL

Figure 5

operating techniques, defective cables, an incorrect power source, poor ground connections, or excessive local interference.

3-2. COMPLETE ALIGNMENT PROCEDURE.

3-3. REMOVAL OF ECG FROM ITS CASE. (See figure 5.)

a. Remove the four flat head screws and two cover positioning screws around the perimeter of the top panel.

b. Place the instrument upside down on a smooth working surface and remove the two screws on the bottom of the cabinet.

c. Lift off cabinet, using a slight rocking motion to prevent the flange of the cabinet from catching on internal mechanical objects. Do not force cover if it does not slip off readily.

NOTE

When replacing unit in cabinet, tighten bottom screws only until washers are snug. Do not apply tension on bottom pan.

3-4. POWER SUPPLY ADJUSTMENTS.

CAUTION

In carrying out the following procedure, exercise special care when making connections to positive voltage terminal 13 of power supply board. Any accidental short circuit of this or any other positive voltage terminal to chassis in the ECG can cause damage to the Zener diode due to excess current flow.

a. Apply 115-volt a-c primary power to ECG through a variable auto-transformer, such as a Variac.

b. Connect negative lead of a 20,000 ohm-per-volt voltmeter (set for 300 to 400-volt d-c range) to terminal 5 of power supply board; connect positive lead to terminal 13 of amplifier board.

c. Connect oscilloscope between terminal 13 of amplifier board and ground. Set sensitivity of oscilloscope to 0.1 volt/inch if possible; if not, set at highest sensitivity and lowest sweep rate. Make certain ECG has had sufficient time to warm up as evidenced by stability of voltmeter indication.

d. Adjust potentiometer marked 260 ADJ. for an indication of 260 volts.

e. Adjust potentiometer marked REG. ADJ. to achieve minimum vertical amplitude of scope trace while varying the primary input (line) voltage from 105 to 130 volts.

f. Repeat steps d and e as required.

g. Disconnect oscilloscope, Variac, and voltmeter.

3-5. SENSITIVITY AND CENTERING CHECK. Set SENSITIVITY control for full gain (maximum clockwise rotation). Rotate CENTERING control and note whether writing stylus can be moved over the full width of the paper. If this cannot be achieved, substitute another 7025 for V2, second amplifier stage. (See figure 9 for tube location.) Investigate further to determine cause if trouble is not corrected.

3-6. STANDARDIZING ADJUSTMENT. (See figure 6.) An external 1-millivolt standard is required for this procedure. To make up an appropriate 1-millivolt standard, connect a 100-ohm, 1/2W, 1% resistor in series with a 100,000-ohm, 1/2W, 1% resistor. Employ this network as a voltage divider and place it across the output terminals of a 1-volt Weston Standard Cell (100-ohm resistor to positive terminal). The voltage across the 100-ohm resistor will be 1-millivolt. Proceed as follows:

a. Plug patient cable in receptacle, J1, (figure 9) and connect all tips (LA, LL, RL and C) together except the RA lead tip. Connect the RA lead tip to the junction of the two resistors; connect the common connection of the other tips to the positive terminal of the cell.

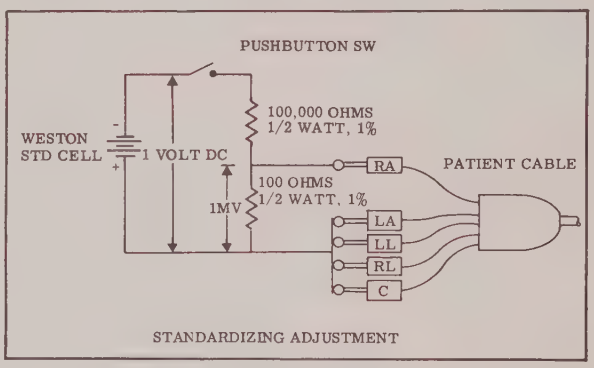


Figure 6

b. Place LEAD SELECTOR switch in lead 1 position.

c. Adjust SENSITIVITY control for 1 centimeter stylus deflection from external standardizing source.

d. Adjust standardization potentiometer R20, shown in figure 3, until the output voltage of the built-in-1-millivolt standard also causes a 1-centimeter stylus deflection.

3-7. FREQUENCY RESPONSE ADJUSTMENT. (See figure 7.)

NOTE

A Hewlett-Packard Model 200 CD Audio Oscillator, or equivalent, is recommended for the following frequency response adjustments and the in-phase rejection test (paragraph 3-8). Connect a voltage divider comprised of one 100-ohm, 1/2W, 1% resistor and one 100,000-ohm, 1/2W, 1% resistor across the output terminals of the signal generator, with the 100-ohm resistor connected to the ground terminal.

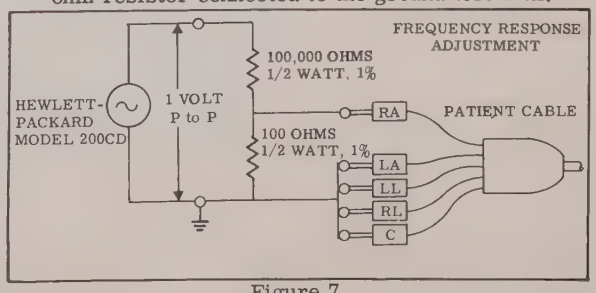


Figure 7

a. Standardize the ECG for 1-centimeter deflection.

b. Connect the RA tip of the patient cable to the junction of the voltage divider resistors. Connect the other tips (LA, LL, RL and C) to the grounded end of the 100-ohm resistor of the divider. Place LEAD SELECTOR switch in lead 1 position. Depress PAPER DRIVE control. (See paragraph 2-9.)

c. Set the frequency of the oscillator to 10 cps and adjust output of oscillator for a 1 centimeter peak-to-peak sine wave tracing. Turn off PAPER DRIVE.

d. Set the frequency of the oscillator to 40 cps; turn on PAPER DRIVE (see paragraph 2-9) and adjust the trimmer marked FREQ. ADJ. until an 8 millimeter peak-to-peak tracing is obtained. Turn off PAPER DRIVE.

3-8. IN-PHASE REJECTION CAPABILITY. (See figure 8.)

a. Repeat steps a, b and c of paragraph 3-7.

b. Return LEAD SELECTOR switch to STD position. Connect the RA and LA lead tips to the ungrounded end of the voltage divider (100,000-ohm resistor); connect all other leads (LL, RL and C) to the grounded 100-ohm resistor at the oscillator terminal. This places an input signal of approximately 1 volt peak-to-peak into the ECG.

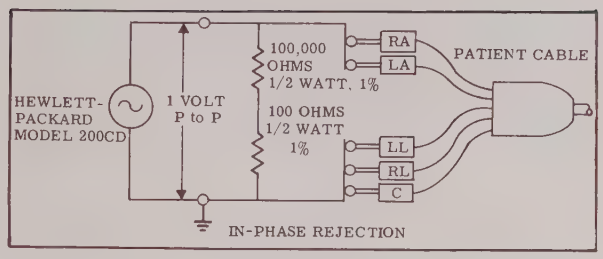


Figure 8

c. Switch to lead 1 and run a trace. A trace of 2 millimeters peak-to-peak amplitude or less is acceptable. (2 millimeters peak-to-peak with 1 volt input equals a rejection ratio of 5000 to 1.)

3-9. PAPER GUIDE BAR ADJUSTMENT. The purpose of the paper guide bar, shown in figure 10, is to

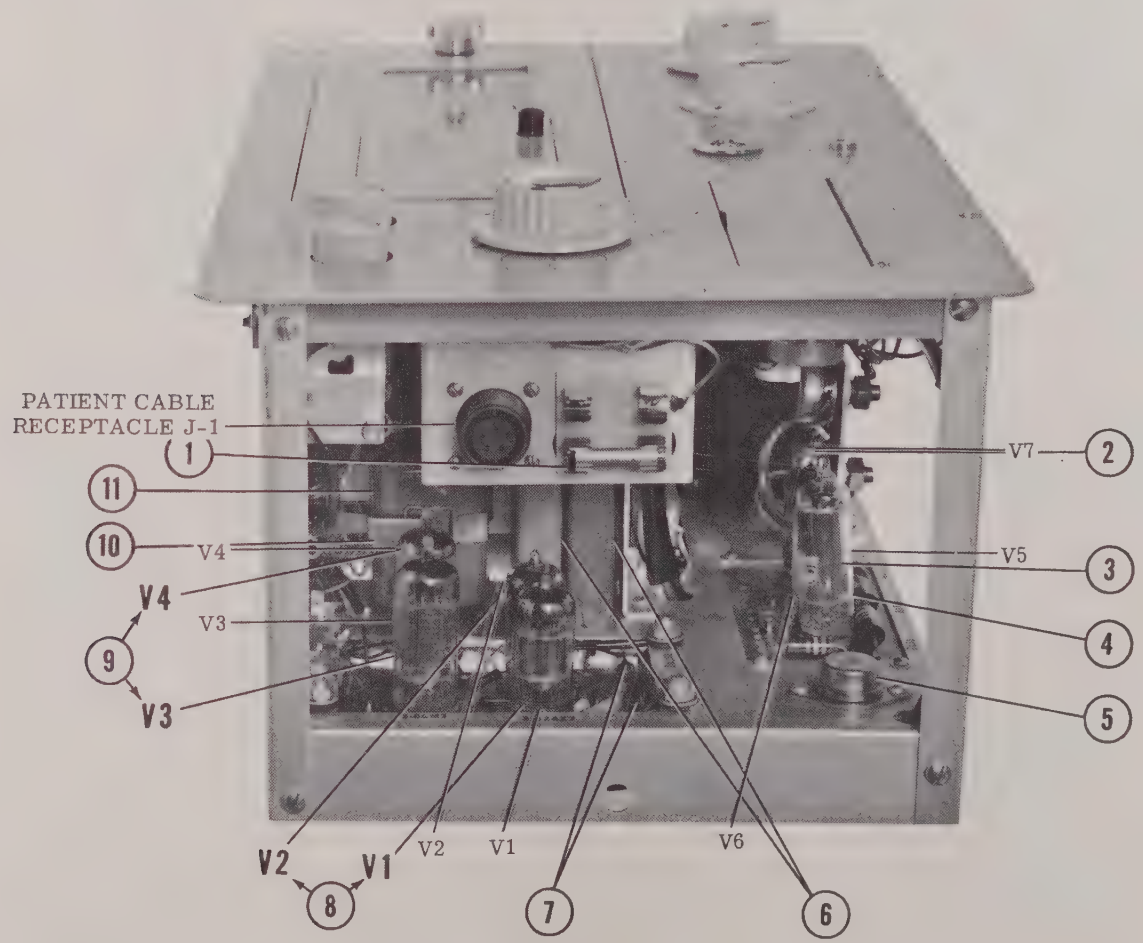


Figure 9

produce a sharp, even crease in the paper as it passes over the writing bar, thereby preventing any irregularities in the surface of the recording paper at this critical point and ensuring that the paper will be fed out evenly. The paper guide bar adjusting screw is also shown in the above illustration. It should be adjusted while the ECG is removed from its case and with the paper loading assembly closed. Adjustment is made with power on and recording paper installed in the normal manner. Adjustment can be made through a hole in the vertical front panel which is provided for this purpose. Make the adjustment in such a manner as to achieve the characteristics stated previously.

3-10. STYLUS PRESSURE ADJUSTMENT. Stylii pressure should be adjusted whenever a new stylus is installed or following the repair and re-alignment of a stylus that has been bent in the course of operation. This adjustment should also be made whenever a trace is not sharp and well-defined and whenever it is necessary to operate with the STYLUS TEMP. control turned up beyond its normal setting. (Before making any adjustment, however, make certain the condition is not caused by an accumulation of wax on the stylii. (See paragraph 3-18.) To adjust pressure on either stylus turn on ECG, set STYLUS TEMP. control to normal setting, and run a trace without any signal input. (Refer to figure 13 for location of stylus pressure adjusting screws.) Turn stylus adjustment screw counterclockwise until stylus is in contact with the paper at the knife edge. Adjustment should be made until a light pressure of the stylus exists on the paper and a sharp, well-defined trace results. Avoid excessive pressure, because this will not only reduce the life of the stylus but will result in poor high frequency response, as indicated by sloping, rounded-off leading

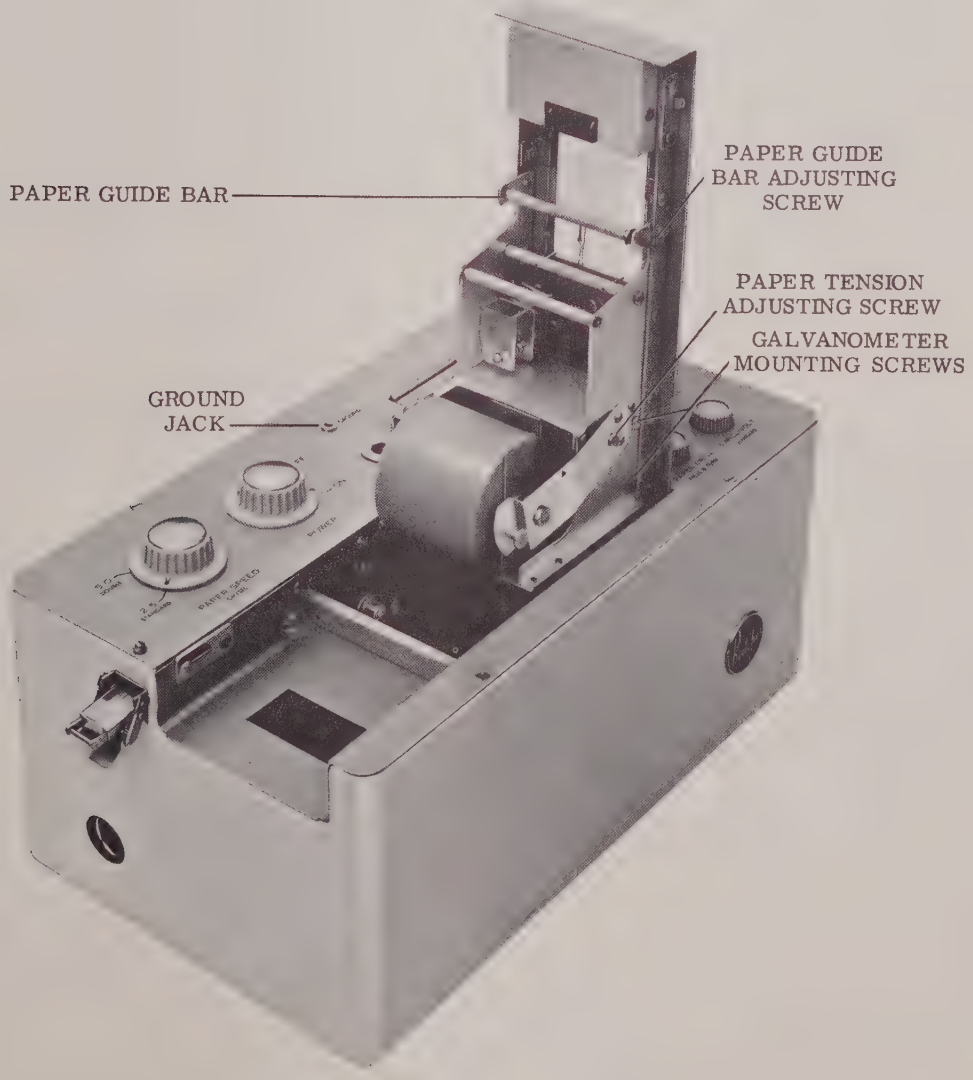


Figure 10.

edges of the standardization pulses. This is caused by excessive friction between the stylus and the recording paper.

3-11. PAPER TENSION ADJUSTMENT. This adjustment establishes the proper paper tension for recording and consists of adjusting the tension of the left flange of the paper holder. If the roll of recording paper is held with insufficient tension, the paper will be fed loosely, which would result in a poor, uneven trace, and might even lead to fouling of the paper. If tension is excessive, the paper drive motor will slow up or even stop completely, depending on the amount of tension present. The latter condition can be detected by observing the 1-second timing marks on a trace. If tension is properly adjusted, the marks occur at 2.5 or 5.0 centimeter intervals, depending on the PAPER SPEED setting; if tension is excessive, spacing of the marks is uneven and decreases gradually as a trace is run. To adjust the paper tension, proceed as follows:

a. Place paper speed in 5.0 cm/scc position, and line voltage at 105 volts. Turn on power, and depress PAPER DRIVE. (See paragraph 2-9.)

b. Employ screwdriver and tighten paper tension adjustment screw (shown in figure 10) with motor running until symptoms of excessive tension are first observed. (Stop PAPER DRIVE and observe trace at intervals as required.) When this occurs, back off slightly in a counterclockwise direction, just sufficient to restore normal 5-centimeter spacing between timing marks.

3-12. PERFORMANCE CHECKS.

3-13. The most reliable performance check is a good recording - one that is normal in every respect. However, if recordings do not appear to be normal, it is recommended that test recordings be made with the patient cable disconnected, as a means of determining ECG performance. The procedure for making the test recordings is given in paragraph 3-16. Before making these recordings, however, make the resistance and voltage checks described in paragraph 3-14 and 3-15, and check the in-phase rejection capability of the ECG, using the procedure given in paragraph 3-8. In addition, make certain that trouble is not caused by a defective stylus, external interference, or by poor electrical contacts (including the ground connection, if used). Test all controls to make certain that they are functioning properly. If any discrepancies are observed take special note of this since such information often provides valuable clues when trouble shooting.

3-14. RESISTANCE MEASUREMENTS. Make the following resistance checks before applying power to the ECG:

a. Measure resistance from terminal 12 of power supply board to chassis. Resistance should be approximately 35,000 ohms.

b. Measure resistance from terminal 13 of power supply board to chassis. Resistance should be approximately 20,000 ohms.

c. Measure resistance from center tap of galvanometer (blue lead) to chassis. Resistance should be approximately 3000 ohms. If this measurement and the preceding ones are not as specified, make proper investigation to discover trouble before proceeding with voltage measurements.

3-15. VOLTAGE MEASUREMENTS.

a. Place LEAD SELECTOR switch in STD position and make certain PAPER DRIVE button is off (not locked in its depressed position). Insert line cord and check for proper polarity.

b. Turn POWER switch to ON. Employ a 20,000 ohms-per-volt voltmeter (negative 25 to 100 volt d-c scale) and measure voltages from terminal 5 of power supply board to chassis, terminal 5 of amplifier board to chassis, and from pin 1 of relay K1 to ground. Identical voltage readings of -10.8 to -11.9 volts should be observed. If any discrepancies are noted, investigate and determine cause before proceeding further.

3-16. TEST RECORDINGS. Test recordings should be made as follows:

TRACE I

a. With LEAD SELECTOR switch in STD position, begin recording and enter standardization pulse, properly adjusted to 1.0 cm deflection (10 small spaces.)

b. Without changing sensitivity, adjust CENTERING so stylus is 1.0 cm above normal centerline. Produce a standardization pulse.

c. Adjust CENTERING so that stylus is 2.0 cm below normal centerline. Produce a standardization pulse. Return stylus to mid-position with CENTERING adjustment.

TRACE II

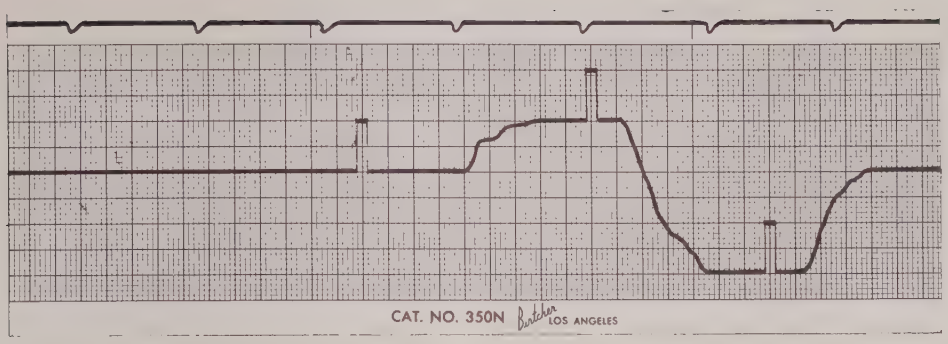
a. With sensitivity remaining as above, depress 1-MILLIVOLT STANDARD button and hold depressed for one second. Release button and continue paper drive for about one second before stopping.

b. Turn SENSITIVITY control fully clockwise. Start paper drive and produce a pulse with the 1-MILLIVOLT STANDARD button. Stop paper drive.

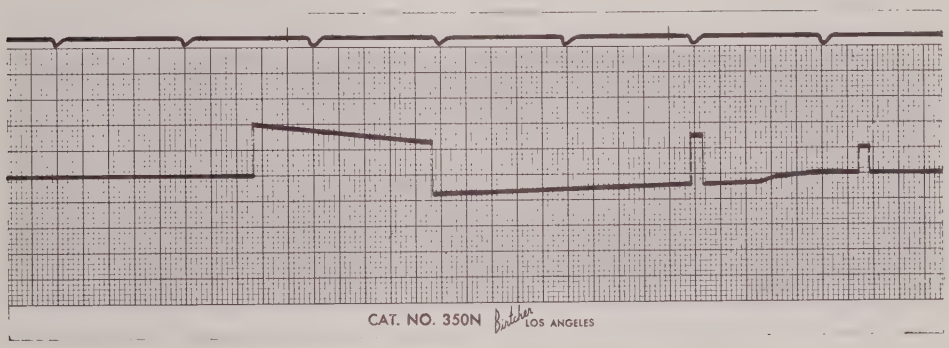
c. Adjust SENSITIVITY control to proper level and produce a 1/2 standardization pulse (vertical deflection of 0.5 cm). Characteristics that should be exhibited by Trace I and Trace II are shown in figure 11. Examples of test recordings that illustrate abnormal trace characteristics that are caused by various troubles are shown in figure 12. These recordings were made under actual recording conditions with patient connected to the ECG. Table 1, Trouble Shooting Chart, lists the symptoms, probable causes and remedies for the troubles illustrated.

3-17. MAINTENANCE PROCEDURES.

3-18. MAINTENANCE OF STYLII. The stylii may become caked with wax from the recording paper after

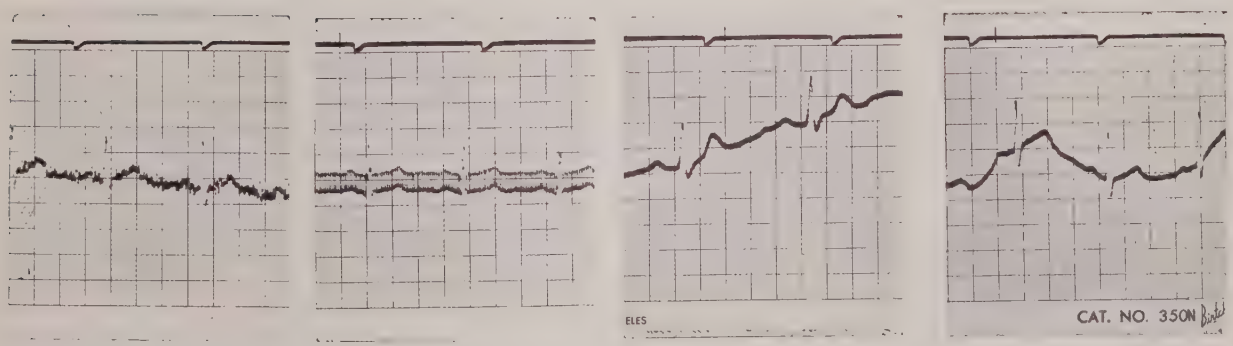


TRACE I



TRACE II

Figure 11.



Muscle tremor | A. C. Interference | Movement of patient | Poor electrode contact

Figure 12.

IMPORTANT: In addition to the "Service Information Tapes" always - if possible - have technician furnish you with a tracing resulting from the Birtcher ECG believed to require service. This action will result in more rapid analysis and repair of difficulties that may be encountered.

TABLE I. TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ECG completely inoperative; indicator lamp in paper compartment not illuminated, paper drive motor does not operate.	Fuse F1 blown.	Replace fuse. If fuse blows again, investigate transformer T1 and B-plus circuits for short circuit.
		Check regulated filament supply.
	Power cable defective or not properly connected.	Check connections; test cable for continuity with ohmmeter.
	Power switch S5 defective.	Replace S1.
Paper drive motor operates but no trace appears.	Transformer T1 defective.	Replace T1, paragraph 3-22.
	Switch S7 defective.	Replace S1.
Same as preceding symptom except only one trace missing.	Stylus open.	Replace stylus (paragraph 3-19.)
ECG test recording has base line only, no standardization pulse; CENTERING control has no effect (causes no displacement of stylus), paper drive motor functions normally.	No B-plus voltage.	Check R38.
	No regulated filament supply.	Check Q3. Check CR2.
	Defective V2.	Check C14.
	No B-minus voltage.	Check C19. Check CR5. Replace V12.
Same as preceding symptom except CENTERING control has normal effect.	Q1 defective; check S2, S3 and C3.	Replace Q1. Replace faulty part.
	Defective V1.	Replace V1.
Standardization pulse has low amplitude with SENSITIVITY control at maximum; CENTERING control does not produce normal stylus displacement, but stylus can be centered properly; stylus does not deflect violently when switching leads.	One or more amplifier tubes weak.	Check tubes by replacement method, using set known to be good.
A-c interference appears on trace in standardizing position.	V1 or V2 defective.	Replace V1 or V2.
	Check C19.	Replace C19.
	Q1 defective.	Replace Q1.
	S1 defective.	Replace S1.
	Line polarity incorrect.	Reverse power plug.
Intermittent operation accompanied by occasional violent deflections of stylus and possibly a-c interference on same leads.	Broken wire in patient cable.	Check cable in accordance with paragraph 3-26.
	Defective galvanometer coil if condition also occurs with LEAD SELECTOR switch in STD position.	Replace galvanometer (paragraph 3-21) after checking circuit with ohmmeter.

TABLE I. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
Intermittent operation accompanied by occasional violent deflections of stylus and possibly a-c interference on same leads. (Cont'd)	Defective tube.	Check by substituting.
Trace made by writing and/or marking stylus appears weak and is not sharply defined; STYLUS TEMP. may require excessive clockwise rotation.	Either stylus may be bent, may have insufficient pressure, may be coated with wax, or may be worn out. Check S7.	Repair stylus, burn off wax coating, readjust pressure, or replace as required. (See paragraphs 3-9, 3-10 and 3-19.) Replace or adjust.
One-second time markers are not spaced evenly; spacing decreases gradually.	Paper tension too tight.	Adjust paper tension. (See paragraph 3-11.)
Paper does not feed evenly.	Paper tension too loose; paper guide bar not properly adjusted.	Adjust paper tension and/or guide bar (paragraphs 3-9 and 3-11).
Writing stylus deflects to maximum position when ECG is turned on; CENTERING control has no effect.	V2, V3 or V4 defective. Capacitor C5 or C6 leaky. Galvanometer coil open, or one half shorted to ground. CENTERING control R25 defective. Plate resistors R30 or R31 open.	Replace defective tube. Replace defective capacitor. Check with ohmmeter and replace galvanometer (paragraph 3-21). Replace R25. Replace R30 or R31.
Fuse F1 blows when POWER switch is turned on.	Transformer T1 shorted. Filter capacitor C16 shorted. Capacitor C4 shorted.	Replace T1. Replace C16. Replace C4.
Fuse F1 blows when PAPER DRIVE button is depressed.	Paper drive motor B2, timing motor B1, or motor capacitor C15 are shorted. Defective CR2, C14.	Replace defective component. Replace defective component.
Standardization pulse not present, otherwise operation is normal.	One-millivolt standardization circuit not functioning.	Check for r-f output with oscilloscope across R22 (with 1 MILLIVOLT STANDARD button depressed). Check continuity of S4 (power off). Check (by replacement method) CR1 and Q2. Make resistance checks of other circuit components (see schematic diagram).
Base line wanders; somatic tremor may or may not be present.	Patient moving, ill-at-ease.	Relax patient; make certain electrodes are not too tight.

prolonged use. This causes a loss of trace definition. If the stylii appear to be coated with a wax residue, open paper loading assembly to clear stylii from paper, start PAPER DRIVE (see paragraph 2-9) and turn STYLUS TEMP. to maximum for a period until wax residue burns off. If trace definition is not restored, make certain stylus pressures are adequate and stylii are making good contact with the paper before replacing either stylus.

3-19. REPLACEMENT OF STYLII. To change either the writing stylus or marking stylus, refer to figure 13, and proceed as follows:

a. Remove stylus access cover.

b. Loosen the two stylus lead terminal screws and disconnect the "pigtails" that are used to provide heating current to the stylus.

c. Loosen stylus clamping screw of writing stylus while gently holding stylus by the base. This will unclamp the stem of the stylus.

d. Hold base of stylus and pull out of clamp.

e. Loosen clamping screw of marking stylus while holding the stylus at the base. (This may be done from the lower side of the paper loading assembly.)

f. Gently grasp stylus and pull out of clamp.

g. Hold a new writing stylus in the manner described and insert stem of the stylus in the clamp. Make certain that the base is roughly parallel with the surface of the galvanometer. Adjust stem position in clamp so that the formed portion of stylus contacts paper, at writing bar over 2.5cm of paper width. Tighten clamping screw.

h. Repeat above procedure for marking stylus.

i. Insert "pigtails" under the terminal screws and tighten to obtain suitable electrical contact. Make certain that position of the "pigtail" wires do not interfere with operation of the stylii.

j. Close paper loading compartment and adjust pressure on the stylus, as described in paragraph 3-10.

3-20. REPLACEMENT OF INDICATOR LAMPS. To replace paper compartment lamp, open paper loading assembly and rotate lamp counterclockwise while pressing in towards socket. When lamp is loose, withdraw it from bayonet type socket. Replace with identical lamp (G.E. #44), reversing the above procedure. To replace the neon polarity indicating lamp on the top panel, first remove the ECG from its case. Exert pressure from the rear of the socket towards the bulb while simultaneously twisting bulb and exerting pressure in the opposite direction, using end of index finger or bulb remover, if available. Replace with identical lamp, type NE 51, reversing the above procedure.

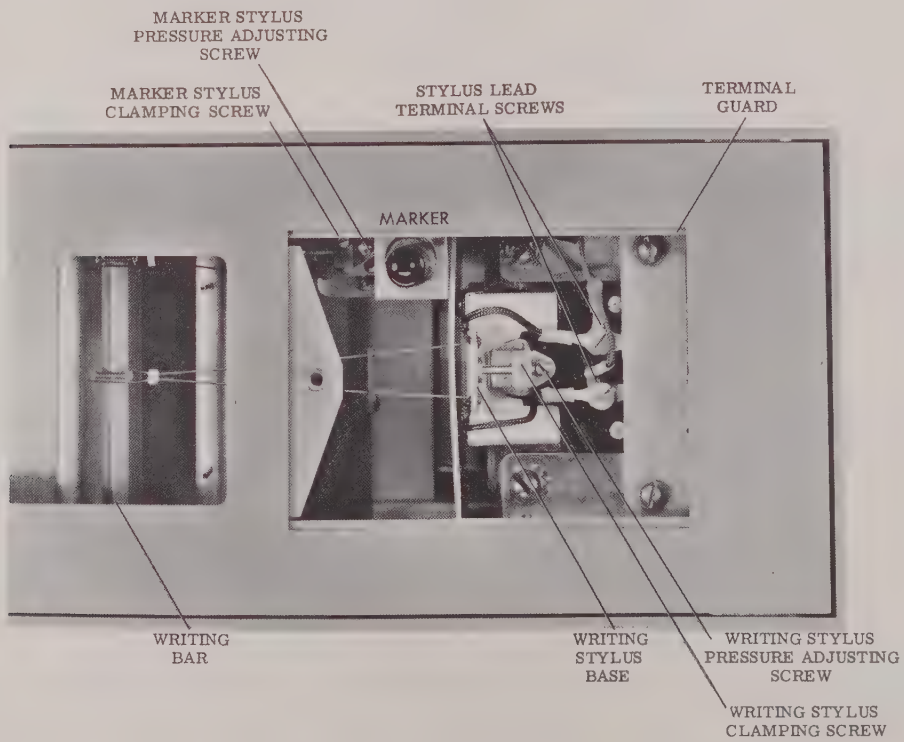


Figure 13.

3-21. REPLACEMENT OF GALVANOMETER.

WARNING

The galvanometer possesses a strong magnetic field that is produced by a permanent magnet. Remove wrist watch before beginning the replacement procedure.

a. Remove ECG from its case. (See paragraph 3-3.)

b. Disconnect stylii lead terminals and move them aside. Loosen stylii clamping screws and carefully remove stylii.

c. Remove galvanometer terminal guard (figure 13).

d. Unsolder colored leads to galvanometer terminals. Tag leads to indicate the terminal from which each was disconnected.

e. Raise paper loading assembly. Place ECG on its left side (patient receptacle facing up). Loosen galvanometer mounting screws and nuts, (figure 10) but do not remove.

f. Reach in through rectangular access hole on bottom of ECG and support galvanometer with right hand. Remove previously-loosened galvanometer mounting screws; using both hands now to support galvanometer, carefully remove it through bottom access hole.

g. In general, installation of the new galvanometer can be accomplished by reversing the removal procedure. Take special precautions, however, to avoid bumping the stylus mounting, which is attached to the delicately-balanced moving coil of the galvanometer.

3-22. POWER TRANSFORMER REPLACEMENT. Should transformer replacement ever become necessary, take special care to observe polarization of the leads that connect to the primary winding. Make certain that brown leads connect to terminal 1 and white leads to terminal 2. Tag all other leads to ensure that no error will be made when reconnecting them to the new transformer.

3-23. TUBE REPLACEMENT. The Birtcher Model 300 Electrocardiograph is designed in such a manner that tube replacement is much less critical than has heretofore been achieved in the field of electrocardiography. In most cases standard commercial tubes can be employed and a high percentage will function satisfactorily. To make certain of tube performance in the ECG, 7025 and 6CM7 tubes are specially "aged" at the factory, and in the process a high degree of stability is attained. For best results, it is recommended, therefore, that these factory-aged and proven tubes be employed for replacement purposes, and that at least one spare for each type be kept on hand.

3-24. REPLACEMENT OF ZENER DIODE. The type 1N1314 Zener diode that is employed in the regulated power supply is specially selected for very close operating tolerances. It is essential, therefore, that this particular item be procured from the Birtcher Corporation in order to insure proper operation of the ECG upon its replacement. In an emergency, however, locally-procured 1N1314 Zeners can be used on a trial and error basis in order to select one that will produce voltages within the required -10.8 to -11.9 volt range at terminal 5 of power supply.

3-25. LUBRICATION. No lubrication is required.

3-26. TESTING PATIENT CABLE. Damaged or broken leads of the patient cable are frequent causes of difficulty. If any apparent erratic trace results from a recording of an electrocardiograph, it is always well to check the patient cable to insure that it is free from damage. To check this cable proceed as follows:

a. Electrically connect all five tips of the patient cable together with a clamp or other suitable device.

b. Insert the patient cable in its mating receptacle in the ECG.

c. Run the ECG on Leads 1, 2 and V for at least two seconds each while moving cables.

d. If a solid, straight base line does not exist on each of these three LEAD SELECTOR switch positions, it is likely that a broken connection exists in the patient cable.

3-27. VOLTAGE AND RESISTANCE MEASUREMENTS. Tube socket voltages and resistances are tabulated in tables 2 and 3. These measurements should serve as a guide when trouble shooting. Measurements were taken from tube socket pins to ground, unless otherwise indicated. Voltage measurements that must be taken with a vacuum tube voltmeter are also indicated.

CAUTION

Do not make any voltage measurements with paper drive motor running or writing stylus (and possibly galvanometer) may be damaged. Do not use 20,000 ohms/voltmeter to measure plate voltage of V3 or V2. The shunting effect of a voltmeter with low resistance causes a sudden unbalance of the two tube sections, which can also cause the above-mentioned damage, due to the violent deflection that will occur.

TABLE 2. TUBE SOCKET VOLTAGE MEASUREMENTS TO GROUND
Stylus Centered on Paper
Line Voltage 115 Volts

TUBE SOCKET PINS									
TUBE	1	2	3	4	5	6	7	8	9
V1 12AX7	140	0	1.6	0	0	140	0	1.6	5.4
V2 12AX7	80	-10.8	-9.8	-10.8	-10.8	80	-10.8	-9.8	-5.4
V3 6CM7	390	76	97	6.3 A.C.	6.3 A.C.	142	76	142	154
V4 6CM7	390	76	87	6.3 A.C.	6.3 A.C.	142	76	142	154

TABLE 3. TUBE SOCKET RESISTANCE MEASUREMENTS
To Ground

TUBE SOCKET PINS									
TUBE	1	2	3	4	5	6	7	8	9
V1 12AX7	1.3M	10K	100K+	4 Ω	4 Ω	1.3M	10K	100K+	0
V2 12AX7	2M	4M	30K	8 Ω	8 Ω	2M	4M	30K	4 Ω
V3 6CM7	30K	2.4M	560K	0	0	1M	2.4M	1M	10K
V4 6CM7	30K	2.4M	560K	0	0	1M	2.4M	1M	10K

SECTION IV
PARTS LIST

4-1. GENERAL. Excluding miscellaneous common hardware, all assemblies and replacement parts for the Birtcher Model 300 Electrocardiograph are listed and illustrated in this section.

4-2. Major assemblies are listed and each assembly broken down to its component parts. Each assembly or part that is illustrated is referenced to the illustration by figure and index number. For example, 6-6 in the "FIG. INDEX NO." column means the item is shown in figure 6, by index number 6.

4-3. Reference designations on items that appear in the schematic diagram will be found in the "REF. DESIG." column of this parts list.

4-4. In the price column, the designation "CAT.", means that item should be priced from the current Standard Catalog Price list.

4-5. All parts and assemblies should be procured from The Birtcher Corporation, 4371 Valley Blvd., Los Angeles 32, California. Replacement parts should be requisitioned by part number, nomenclature and quantity desired in addition to the Model and Serial number of equipment.

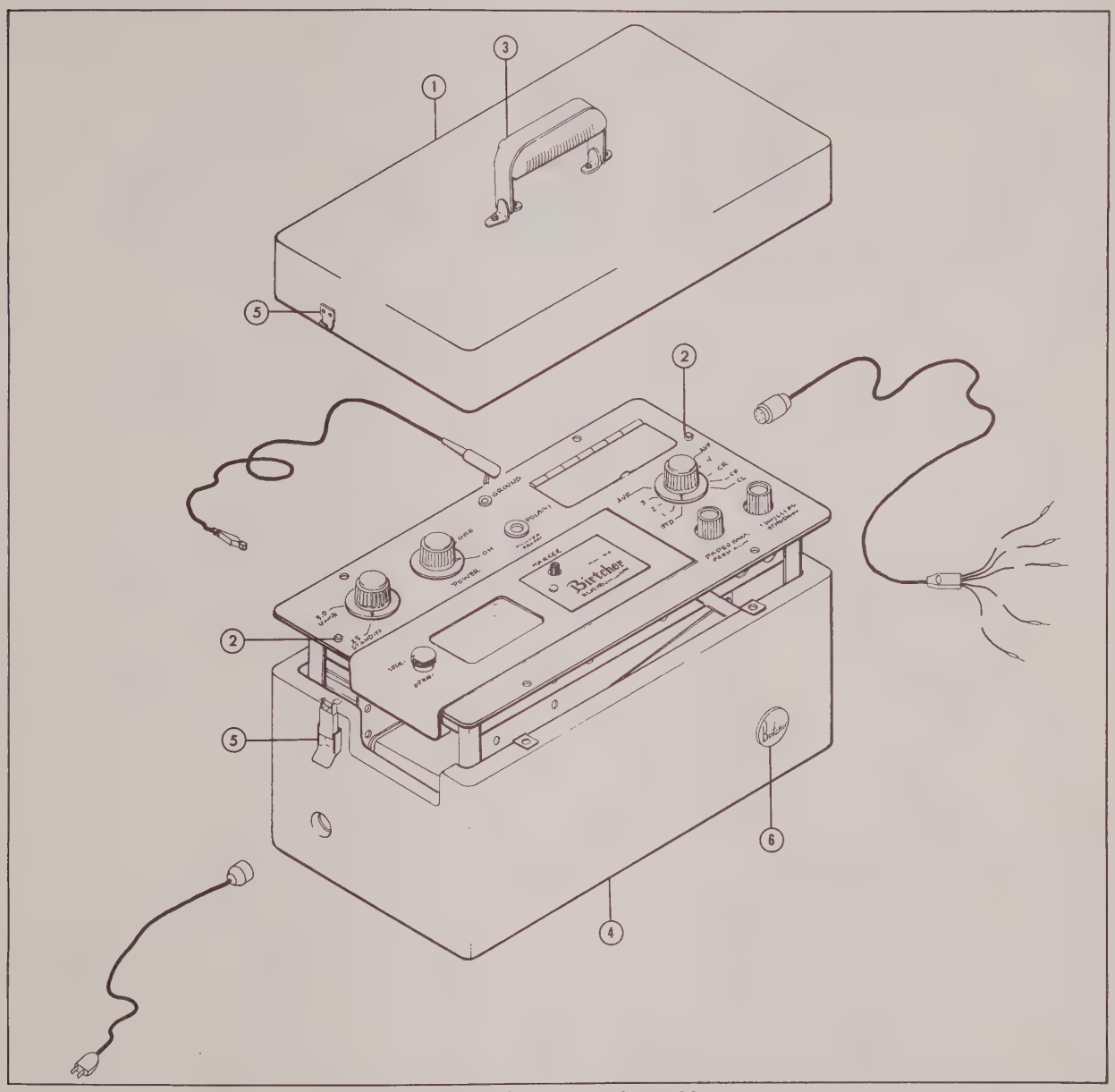


Figure 14. Major Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG	QTY	PRICE EACH
		MAJOR ASSEMBLY			
14-1	21192	COVER		1	$20.00
-2	19005-82	SPACER, Positioning screw		2	.10
-3(*)	BE2-6	HANDLE		1	3.00
-4	1780	CABINET, BODY		1	30.00
-5(*)	DM23-2	LATCH		2	1.50
-6	20058	EMBLEM (Exchange only)		1	2.50

(*) SEE ADDENDUM

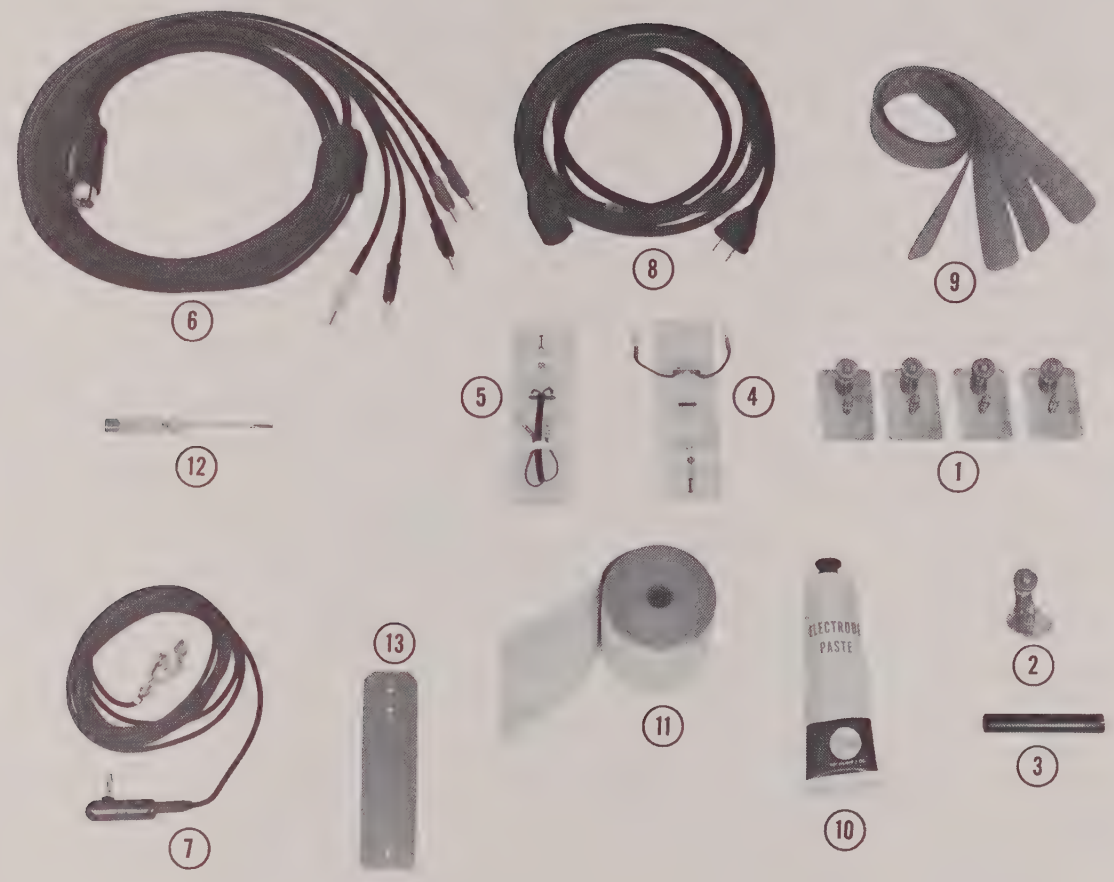


Figure 15. Accessory List

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		ACCESSORIES LIST			
15-1	301	LIMB ELECTRODES		4	Cat.
-2	302	CHEST ELECTRODE		1	Cat.
-3	303	CHEST ELECTRODE HANDLE		1	Cat.
-4	~~305~~ 310	WRITING STYLUS		2*	Cat.
-5	~~306~~ 311	MARKING STYLUS		2*	Cat.
-6	315	PATIENT CABLE		1	Cat.
-7	317	GROUNDING CORD		1	Cat.
-8	318	POWER CORD		1	Cat.
-9	243	ELECTRODE STRAPS		4	Cat.
	319	LINE FUSE		1*	Cat.
	345	12 LEAD MTG. FOLDER		6**	Cat.
-10	347	ELECTRODE PASTE, Tube		1	Cat.
-11	350-N	CHART PAPER, 150' Roll		1	Cat.
-12	DJ3-1	SCREW DRIVER		1	Cat.
-13	21259	ACCESSORY STRAP		1	Cat.
	CB8-1	PLASTIC COVER		1**	Cat

* One in unit
** Not shown
All accessories are furnished as part of initial equipment

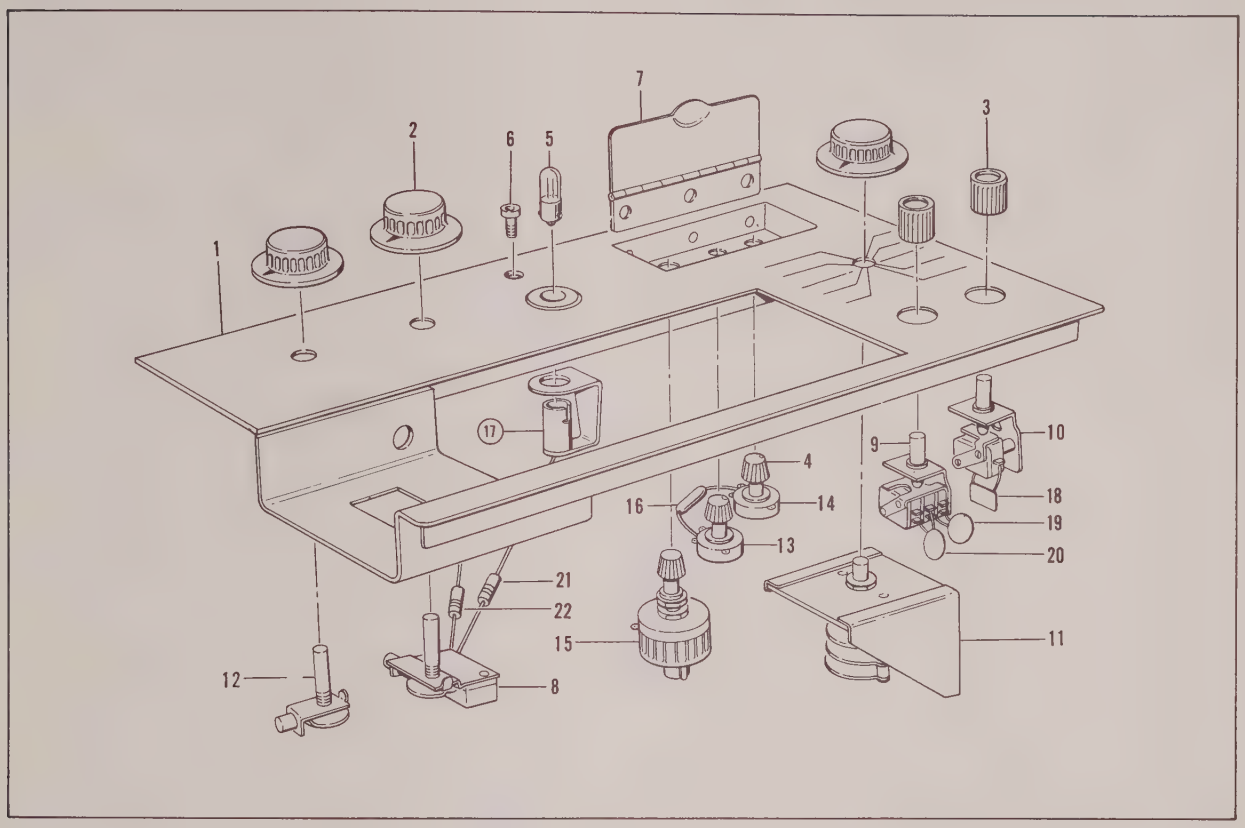


Figure 16. Control Panel Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CONTROL PANEL ASSEMBLY			
16-1	1765	PANEL		1	$25.00
-2(*)	21868	KNOB		3	.90
-3	BE1-7	KNOB		2	1.00
-4(*)	19083	KNOB		3	.75
-5	BF1-10	LAMP, Neon, #NE51	DS1	1	.75
-6	19364-1	JACK, Ground		1	.25
-7	1766	CONTROL LID		1	7.25
-8	1769	SWITCH, Power	S5	1	7.75
-9	1771	SWITCH, Paper drive	S3, S6, S7	1	10.75
-10	1772	SWITCH, Standard	S4	1	5.00
-11	1773	SWITCH, Lead selector	S1, S2	1	26.50
-12	1797	SWITCH, Speed		1	3.00
-13(*)	BI6-8	POTENTIOMETER, Sensitivity control	R27	1	1.00
-14	BB7-16	POTENTIOMETER, Centering control	R25	1	1.00
-15(*)	BI6-7	POTENTIOMETER, Stylus temperature	R39	1	7.50
-16(*)	BI1-95	RESISTOR, 150K, 1/2 W	R26	1	.75
-17	BF2-3	SOCKET, Neon lamp		1	.50
-18	BB6-10	CAPACITOR, .047 mfd, 300 V	C10	1	.50
-19	BB6-8	CAPACITOR, .01 mfd, 600 V	C13	1	.20
-20	BB6-8	CAPACITOR, .01 mfd, 600 V	C3	1	.50
-21	BI1-80	RESISTOR, 220K, 1/2W	R36	1	.75
-22	BI1-69	RESISTOR, 100K, 1/2W	R37	1	.20

(*) SEE ADDENDUM

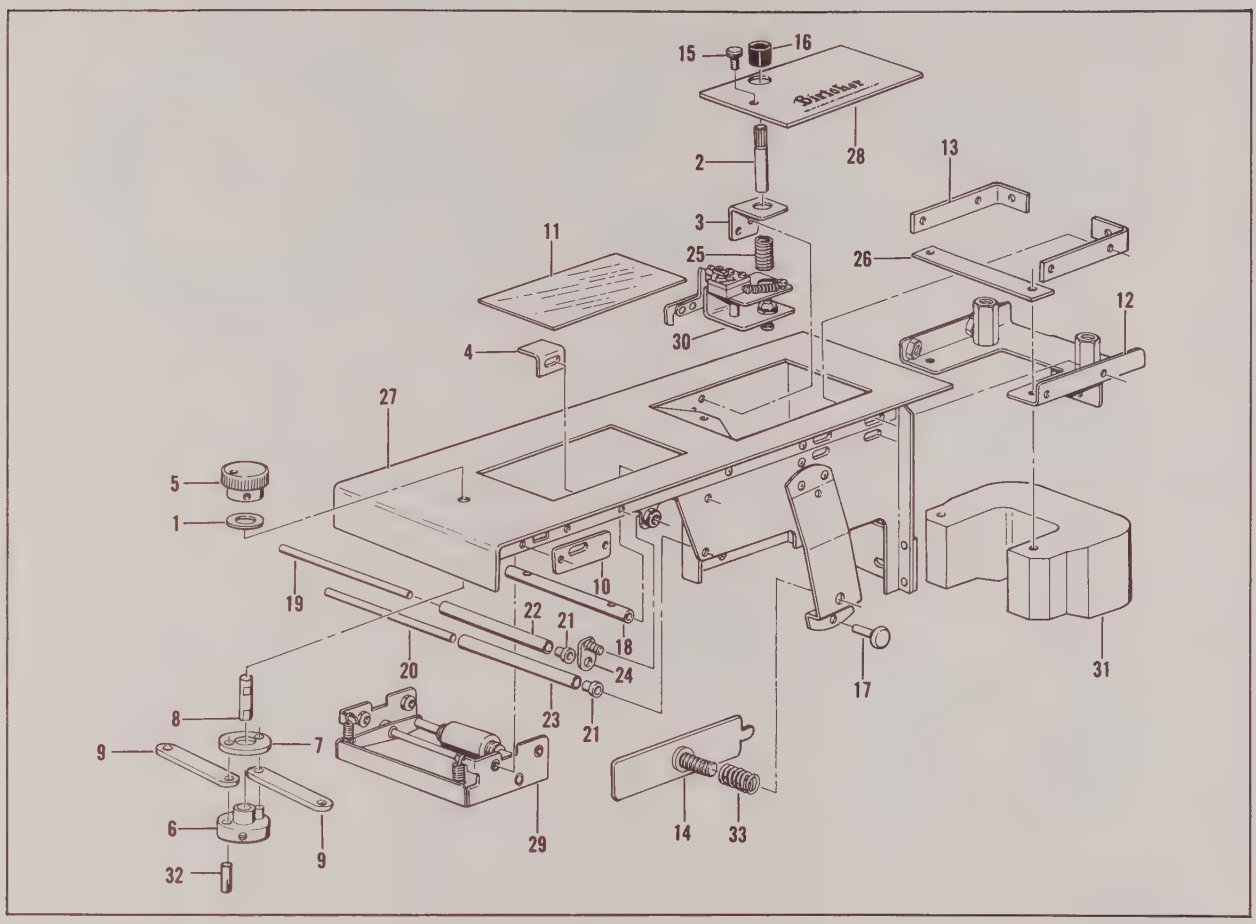


Figure 17. Chart Door Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG	QTY	PRICE EACH
		CHART DOOR ASSEMBLY			
17-	1764	CHART DOOR ASSEMBLY		1	Ref
-1	19260-30	WASHER, Felt		1	$ .10
-2	21185	SHAFT, Marker		1	.30
-3	21186	ANGLE, Marker shaft		1	.20
-4	21195	CLIP, Window		2	.25
-5	21196	KNOB, Latch		1	2.00
-6	21197	DISC, Cam		1	1.25
-7	21198	DISC, Spacer		1	.75
-8	21233	SHAFT, Latch		1	.20
-9	21200	ROD, Latch		2	.50
-10	21201	PLATE, Latch adj		2	.50
-11	21203	WINDOW		1	1.25
-12(*)	2039	BRACKET, Galvanometer		1	3.50
-13	21207	BRACKET, Hinge		2	1.00
-14(*)	2106	PLATE, Roll guide		2	4.50
-15	21205	SCREW		1	.50
-16	BE3-1	BUTTON, Push		1	.15
-17	21213	KNOB, Paper release		1	1.25
-18	21214	ROD, Stylus restrain		1	.75
-19	21216	SHAFT, Adj. roller		1	.20
-20	21217	SHAFT, Guide roller		1	.25
-21	21218	BUSHING, Roller end		4	.15

(*) SEE ADDENDUM

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CHART DOOR ASSEMBLY (continued)			
17-22	21219	ROLLER, Adj		1	$ .50
-23	21220	ROLLER, Guide		1	.30
-24	21221	SCREW, Adj		1	.25
-25	21225	SPRING, Marker shaft		1	.10
-26	21234	GUARD, Terminal		1	.10
-27	1760	FRAME		1	20.00
-28	1761	PLATE, Access		1	5.00
-29	1762	BOX, Pressure roller		1	10.00
-30	1776	MARKER ASSEMBLY		1	13.50
-31	1791	GALVANOMETER	G1	1	175.00
-32	DL7-11	PIN		2	.10
-33(*)	21471	SPRING, Stud		1	.20
		CHASSIS ASSEMBLY			
18-1	BQ-5	TIMING MOTOR	See figure 22-2		
	BQ-8	TIMING MOTOR (50 cycle only)			Ref
-2	21182	CAM		1	$ .50
-3	21122	PARTITION, Left		1	2.50
-4	21121	PARTITION, Right		1	3.50
-5	DE2-4	TERMINAL BOARD		1	.40
-6	BJ1-4	RELAY	See figure 20-11		
-7	BB3-8	CONDENSER	See figure 20-6		
-8	BL4-11	TRANSISTOR	See figure 20-5		
-9	BB4-4	TRIMMER CONDENSER	C11	1	1.25
-10	DE2-6	TERMINAL BOARD		1	.15
-11	1786	AMPLIFIER ASSEMBLY	See figure 21-3		
-12	BL1-39	TUBE, 6CM7	See figure 20-9		
-13	BF2-4	SOCKET, Pilot lamp	See figure 22-3		
-14	BL1-40	TUBE, 12AX7/7025	See figure 20-8		
-15	BN1-4	SOCKET, 8 pin relay		1	.50
-16	1787	POWER SUPPLY ASSEMBLY	See figure 21-4		
-17	BL1-38	TUBE, 6AS5	See figure 20-4		
-18	BL1-37	TUBE, 6AU6	See figure 20-3		
-19	BL1-36	TUBE, 5651	See figure 20-2		
-20	1785	FILTER CONDENSER BOARD	See figure 21-1		
-21	1781	RESISTOR BOARD	See figure 21-5		
-22	BL2-1	RECTIFIER	See figure 21-8		
-23	BQ-6	DRIVE MOTOR	See figure 19-7		
-24	2217	RECTIFIER (See TD16116)	See figure 19-6		
-25	BB12-5	CAPACITOR, MOTOR 1.6 MFD	See figure 19-5		
-26	BI6-12	POTENTIOMETER	See figure 22-9		
-27	BI6-32	POTENTIOMETER	See figure 22-8		
-28	21138	BRACKET	See figure 22-7		
-29	BR1-11A	TRANSFORMER	See figure 22-6		
-30	1783	CHASSIS		1	9.00
-31	BU10-4	RECEPTACLE	See figure 19-3		
-32	1803	FUSE MOUNTING BLOCK	See figure 22-5		
-33	BS1-2	FUSE, 1 amp	See figure 22-4		
-34	1775	DRIVE DRUM	See figure 19-4		
-35	1784	GEAR BOX	See figure 19-2		
-36(*)	1851	BRAKE, Electronic motor		1	7.50
-36.1(*)	BB8-15	CAPACITOR, 200 mfd, 200V	C20	1	2.50
-36.2(*)	BI3-9	RESISTOR, 220 ohms, 1W	R52	1	.25
-36.3(*)	BL2-3	RECTIFIER, 1N1084	CR6	1	5.00
-37	BF1-9	LAMP, Filament, #44	DS2	1	.25

(*) SEE ADDENDUM

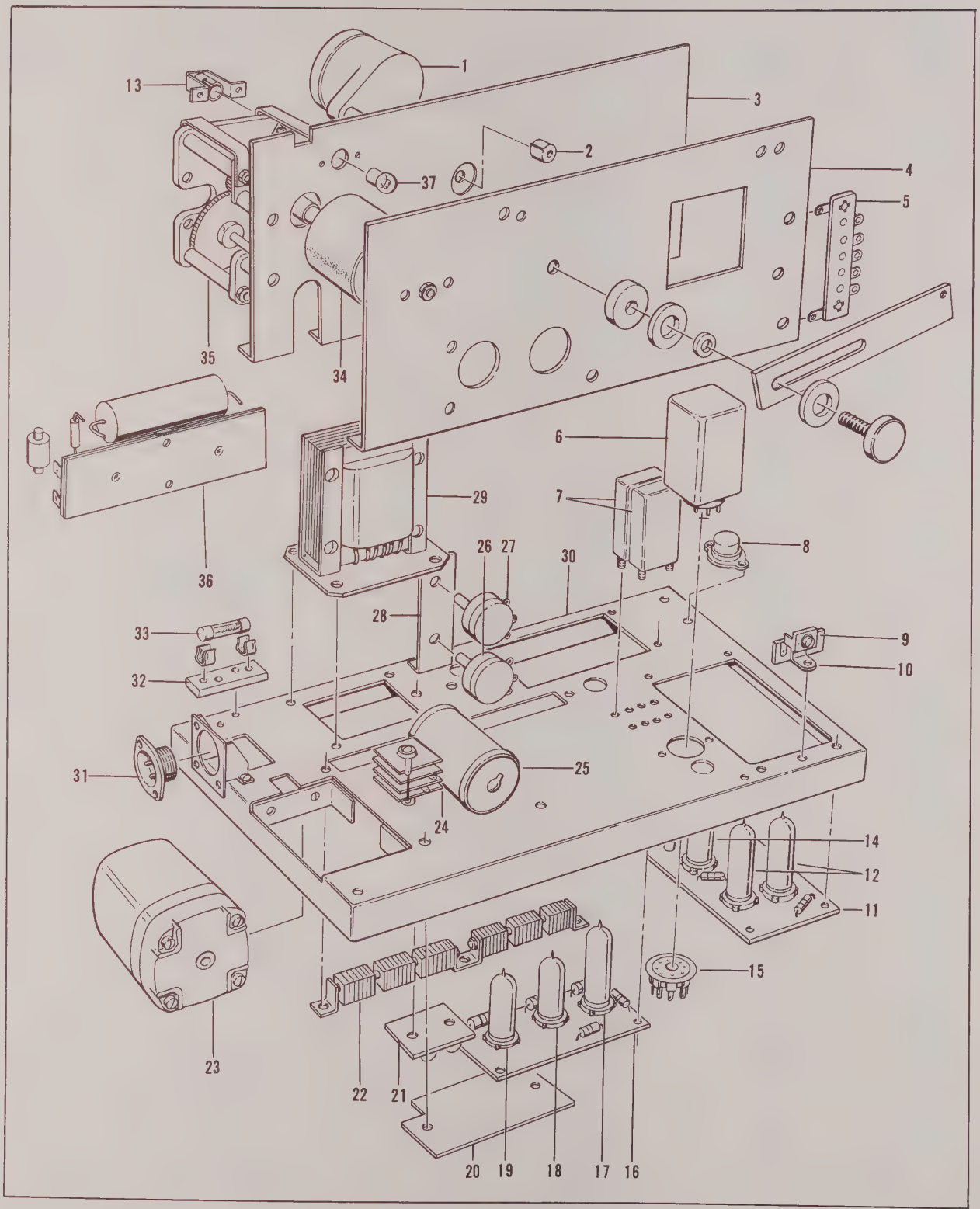


Figure 18. Chassis Assembly

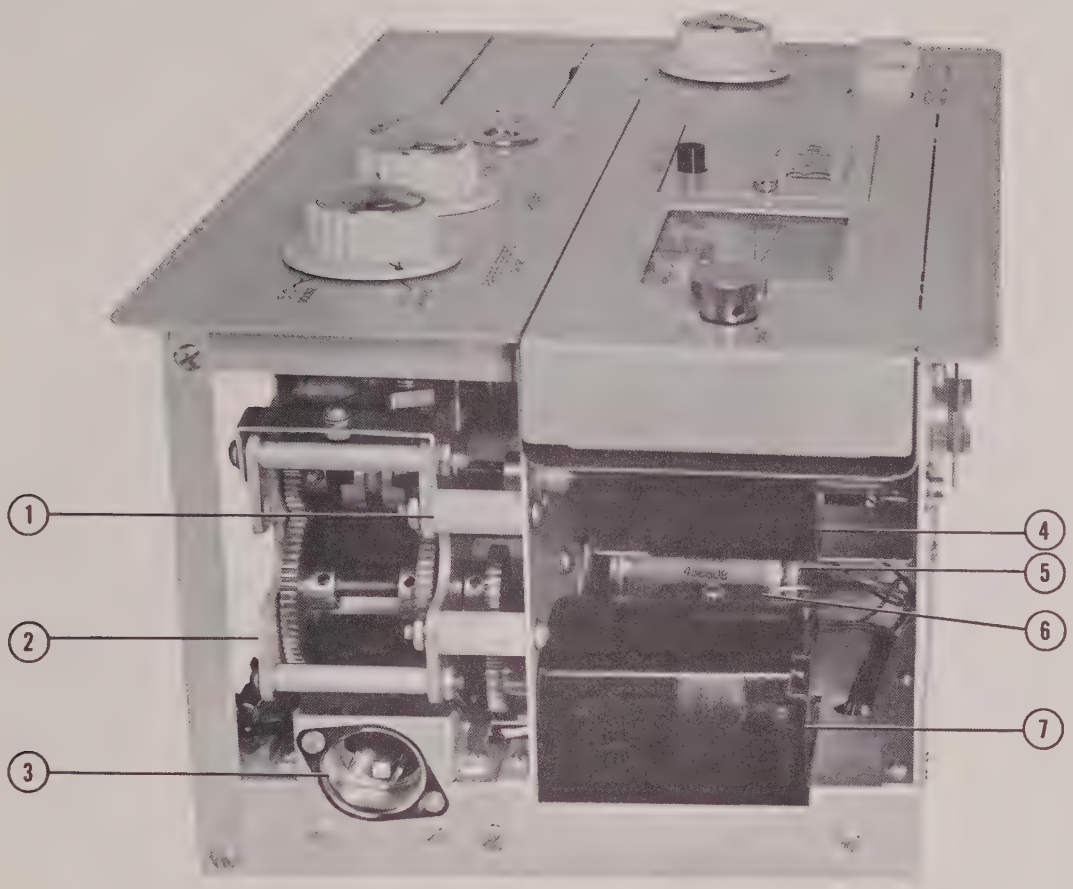


Figure 19. Chassis Assembly
Left Side View

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG	QTY	PRICE EACH
		CHASSIS ASSEMBLY LEFT SIDE VIEW			
19-1	21156	SPACER		4	$ .30
-2	1784	GEAR BOX		1	33.00
-3(*)	BU10-4	115 v RECEPTACLE	J2	1	2.75
-4	1775	DRIVE DRUM		1	6.75
-5(*)	BQ-16	CONDENSER	C15	1	7.50
-6(*)	2217	RECTIFIER (See TD16116)	CR2	1	4.20
-7	BQ-6	DRIVE MOTOR	B2	1	90.00
	BQ-7	DRIVE MOTOR (50 cycle)			Ref.

(*) SEE ADDENDUM

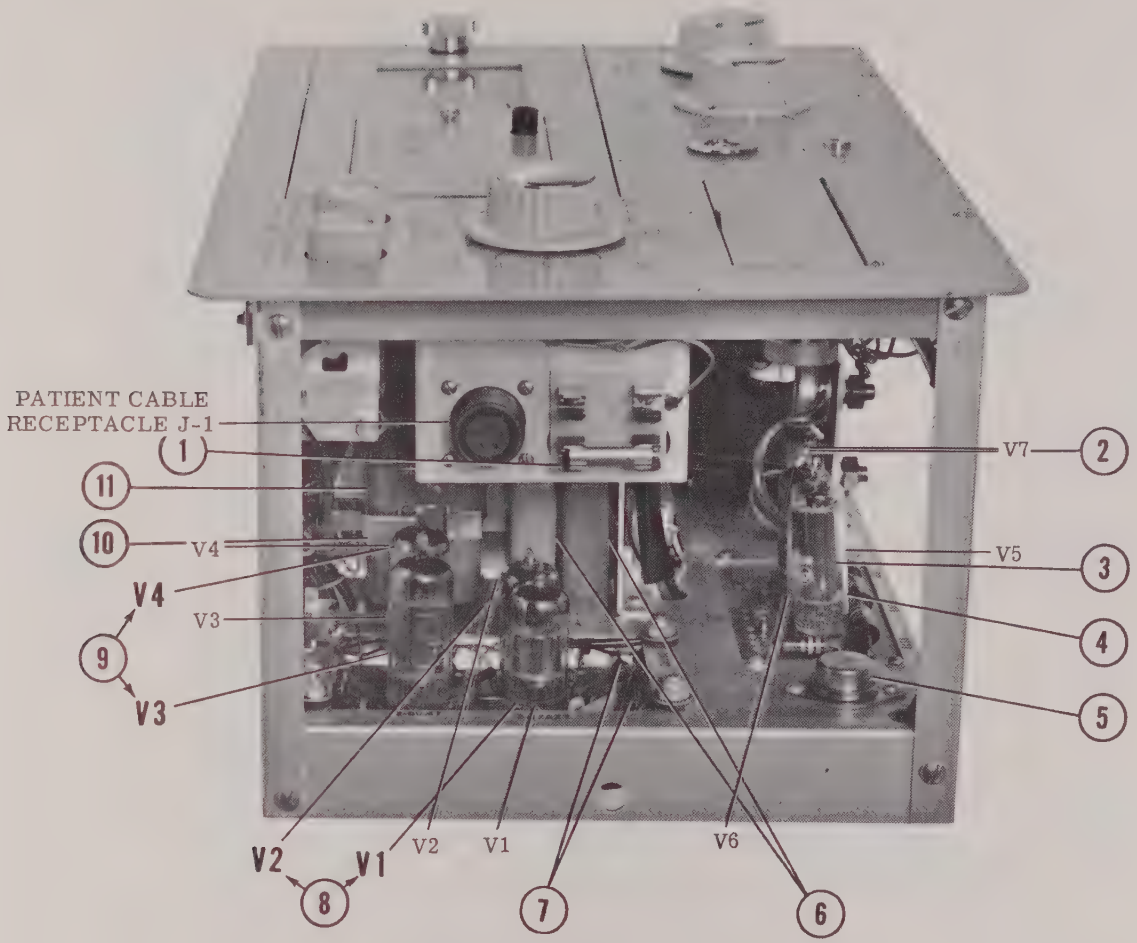


Figure 20. Chassis Assembly
Right Side View

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CHASSIS ASSEMBLY RIGHT SIDE VIEW			
20-1	21257	FUSE JUMPER		1	$ .20
-2	BL1-36	TUBE, 5651	V7	1	Cat.
-3	BL1-37	TUBE, 6AU6	V6	1	Cat.
-4	BL1-38	TUBE, 6AS5	V5	1	Cat.
-5(*)	BL4-11	TRANSISTOR, 2N2869	Q3	1	7.50
-6	BB3-8	CONDENSER, .5 mfd 300 VDC	C5, C6	2	12.50
-7	BL4-1	TRANSISTOR, 2N292	Q1, Q2	2	5.50
-8	BL1-40	TUBE, 12AX7/7025	V1, V2	2	Cat.
-9	BL1-39	TUBE, 6CM7	V3, V4	2	Cat.
-10(*)	DC5-10	CLAMP, Relay		1	1.50
-11	BJ1-4	RELAY	K1	1	30.00

(*) SEE ADDENDUM

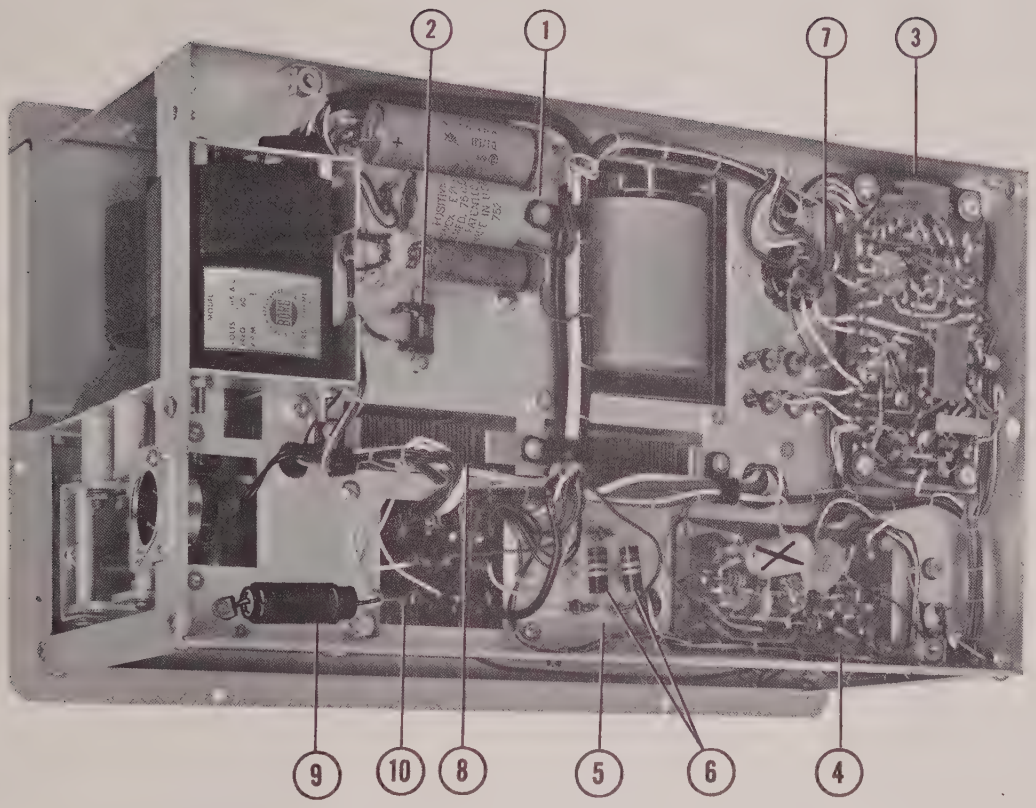


Figure 21. Chassis Assembly
Bottom View

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CHASSIS ASSEMBLY BOTTOM VIEW			
21-1	1785	FILTER CONDENSER BOARD		1	$ 6.50
21-1.1	BB8-3	CAPACITOR, 40 mfd, 450 vdc, electro	C16	1	2.00
21-1.2	BB3-7	CAPACITOR, 4 mfd, 450 vdc, electro	C4	1	1.25
21-1.3(*)	BB8-39	CAPACITOR, 100 mfd, 75 vdc, electro	C14	1	1.50
21-2	BI1-63	RESISTOR, 3K, 10W	R35	1	2.00
21-3	1786	AMPLIFIER ASSEMBLY		1	75.00
21-3.1	21224	BOARD, Printed		1	12.00
21-3.2	21263	PRINTED NETWORK	Z1	1	1.00
21-3.3	21264	PRINTED NETWORK	Z2	1	2.00
21-3.4(*)	EB6-3	RUBBER BUMPER.		4	.25
21-3.5	BN1-11	SOCKET, 9 pin tube		2	.40
21-3.6	BN1-13	SOCKET, 3 pin tube		2	.40
21-3.7	BN1-12	SOCKET, 9 pin tube		2	.40
21-3.8	BL4-3	XTAL DIODE, IN34A	CR1	1	1.50
21-3.9	BC1-8	COIL, R. F. Choke, 2.5 mh	L1, L2	2	2.50

(*) SEE ADDENDUM

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CHASSIS ASSEMBLY BOTTOM VIEW (continued)			
21-3.10	BB6-6	CAPACITOR, Ceramic, 100 mmfd 500 V	C7,C9	2	$ .20
21-3.11(*)	BI2-2	RESISTOR, 33.2K ohm, 1/2 W . . .	R19,R21,R24	3	.55
21-3.12(*)	BI2-20	RESISTOR, 8250 ohm, 1/2 W	R23	1	.65
21-3.13	BB7-19	POTENTIOMETER, 100 ohm, 1/4 W	R20	1	6.50
21-3.14(*)	BI1-136	RESISTOR, 26.7K ohms, 1/2 W . . .	R15,R18,R22	3	.55
21-3.15(*)	BI2-3	RESISTOR, 47.5K ohms, 1/2 W . . .	R16	1	1.25
21-3.16(*)	BI2-31	RESISTOR, 4.02M ohms, 1/2 W . .	R13,R14	2	.65
21-3.17(*)	BI2-14	RESISTOR, 332K ohms, 1/2 W . . .	R17,R30,R31	3	.55
21-3.18	BI1-59	RESISTOR, 681K ohms, 1/2 W . . .	R32,R33	2	.55
21-3.19	BI1-78	RESISTOR, 562K ohms, 1/2 W . . .	R34	1	.65
21-3.20(*)	BI2-74	RESISTOR, 475K ohms, 1/2 W . . .	R28,R29	2	.55
21-3.21	BI1-58	RESISTOR, 1.2M ohms, 1/2 W . . .	R11,R12	2	.55
		CAPACITOR, Ceramic, 600 mmfd, 600 V	C12	1	
21-3.22(*)	BB6-9	CAPACITOR, Ceramic, 750 mmfd, 600 V	C12 Replacement		.25
21-3.23	BB6-5	CAPACITOR, Ceramic, 0.001 mfd, 600 V	C2,C8	2	.20
21-4	1787	POWER SUPPLY ASSEMBLY		1	45.00
21-4.1	21223	BOARD, Printed circuit		1	7.50
21-4.2	BB6-8	CAPACITOR, Ceramic, 0.01 mfd, 600 V	C17	1	.20
21-4.3(*)	BI3-16	RESISTOR, 130K ohms, 1 W	R41,R47	2	.35
21-4.4(*)	BI4-17	RESISTOR, 12K ohms, 2 W	R50,R51	2	.30
21-4.5(*)	BI3-17	RESISTOR, 47K ohms, 1 W	R43	1	.30
21-4.6(*)	BI3-18	RESISTOR, 270K ohms, 1 W	R45	1	.30
21-4.6(*)	BI4-11	RESISTOR, 39K ohms, 2 W	R44	1	.30
21-4.7(*)	BI3-19	RESISTOR, 68K ohms, 1 W	R46,R49	2	.20
21-4.8(*)	BL3-2	ZENER DIODE, 1N1314	CR5	1	12.50
21-4.9	BB6-11	CAPACITOR, Ceramic, 0.1 mfd, 500 V	C18	1	1.50
21-4.10	BN1-15	SOCKET, 7 pin tube		1	.30
21-4.11	BN1-14	SOCKET, 7 pin tube		2	.25
21-5	1781	RESISTOR BOARD		1	.50
21-6(*)	BI4-12	RESISTOR, 27K, 2 W	R8,R9	2	.75
21-7(*)	BI4-13	RESISTOR, 1800 ohms, 2 W	R10	1	.50
21-8	BL2-1	RECTIFIER	CR3,CR4	6	1.50
21-9(*)	BB8-8	CAPACITOR, Electro, 100 mfd, 25V . . Replaces BB3-9 & relocated on chassis	C19	1	1.35
21-10	BI1-90	RESISTOR, 22 ohms, 1/2 W	R38	1	.20

(*) SEE ADDENDUM

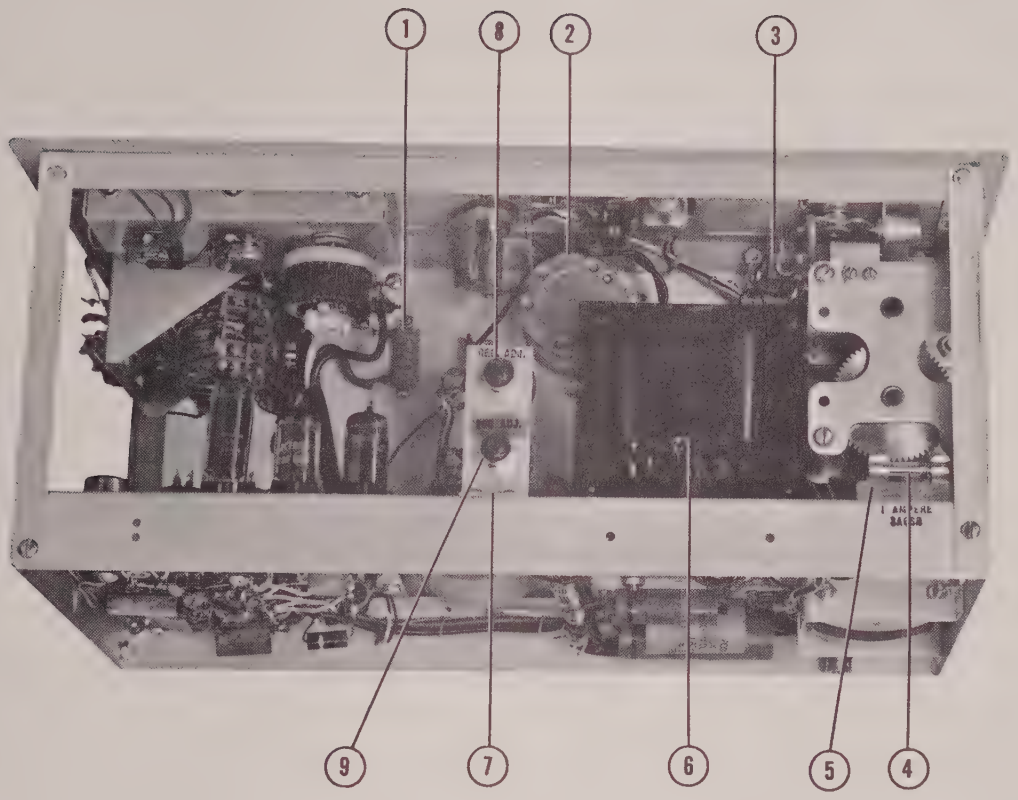


Figure 22. Chassis Assembly
Rear View

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY	PRICE EACH
		CHASSIS ASSEMBLY REAR VIEW			
22-1(*)	BI5-1	RESISTOR, .3 ohm 15 W	R40	1	$ 3.00
-2	BQ-5	TIMING MOTOR.	B1	1	12.00
-3(*)	BF2-4	PILOT LAMP SOCKET		1	.50
-4	BS1-2	FUSE, 1 amp. (Cat. #319)	F1	1	Cat.
-5	1803	FUSE MOUNTING BLOCK		1	1.25
-6(*)	BR1-11A	TRANSFORMER	T1	1	40.00
(*)	BR5-11A	TRANSFORMER, Special voltage			Ref
-7	21138	BRACKET		1	.25
-8(*)	BI6-32	POTENTIOMETER.	R42	1	4.50
-9(*)	BI6-12	POTENTIOMETER.	R48	1	4.50

(*) SEE ADDENDUM

CROSS REFERENCE

Wiring diagram-Parts List

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
B1	BQ-5	22-2
B2	BQ-6	19-7
C1***	BB6-8	16-11
C2	BB6-5	21-3
C3	BB6-8	16-20
C4	BB3-7	21-1
C5	BB3-8	20-6
C6	BB3-8	20-6
C7	BB6-6	21-3
C8	BB6-5	21-3
C9	BB6-6	21-3
C10	BB6-10	16-18
C11	BB4-4	18-9
C12	BB6-5	21-3
C13	BB6-8	16-19
C14	BB8-39	21-1
C15	BQ-16	19-5
C16	BB8-3	21-1
C17	BB6-8	21-4
C18	BB6-11	21-4
C19	BB8-8	21-9
C20	BB8-15	18-36
CR1	BL4-3	21-3
CR2	2217	19-6
CR3	BL2-1	21-8
CR4	BL2-1	21-8
CR5	BL3-2	21-4
CR6	BL2-3	18-36
DS1	BF1-10	16-5
DS2	BF1-9	18-37
F1	BS1-2	22-4
G1	1791	17-31
J1***	BU1-7	16-11
J2	BU10-4	19-3
J3	BJ1-4	20-11
L1	BC1-8	21-3
L2	BC1-8	21-3

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
Q1	BL4-1	20-7
Q2	BL4-1	20-7
Q3	BL4-11	20-5
R1***	BI1-60	16-11
R2***	BI1-60	16-11
R3***	BI1-60	16-11
R4***	BI1-61	16-11
R5***	BI1-61	16-11
R6***	BI1-62	16-11
R7***	BI1-61	16-11
R8	BI4-12	21-6
R9	BI4-12	21-6
R10	BI4-13	21-7
R11	BI1-58	21-3
R12	BI1-58	21-3
R13	BI2-31	21-3
R14	BI2-31	21-3
R15	BI1-136	21-3
R16	BI2-3	21-3
R17	BI2-14	21-3
R18	BI1-136	21-3
R19	BI2-2	21-3
R20	BB7-19	21-3
R21	BI2-2	21-3
R22	BI1-136	21-3
R23	BI2-20	21-3
R24	BI2-2	21-3
R25	BB7-16	16-14
R26	BI1-95	16-16
R27	BI6-8	16-13
R28	BI2-74	21-3
R29	BI2-74	21-3
R30	BI2-14	21-3
R31	BI2-14	21-3
R32	BI1-59	21-3
R33	BI1-59	21-3

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
R34	BI1-78	21-3
R35	BI1-63	21-2
R36	BI1-80	16-21
R37	BI1-69	16-22
R38	BI1-90	21-10
R39	BI6-7	16-15
R40	BI5-1	22-1
R41	BI3-16	21-4
R42	BI6-32	22-8
R43	BI3-17	21-4
R44	BI4-11	21-4
R45	BI3-18	21-4
R46	BI3-19	21-4
R47	BI3-16	21-4
R48	BI6-12	22-9
R49	BI3-19	21-4
R50	BI4-17	21-4
R51	BI4-17	21-4
R52	BI3-9	18-36
S1***	BK3-7	16-11
S2***	BK4-5	16-11
S3*	BK4-5	16-9
S4**	BK4-5	16-10
S5	BK4-5	16-8
S6*	BK4-5	16-9
S7*	BK4-5	16-9
T1	BR1-11A	22-6
V1	BL1-40	20-8
V2	BL1-40	20-8
V3	BL1-39	20-9
V4	BL1-39	20-9
V5	BL1-38	20-4
V6	BL1-37	20-3
V7	BL1-36	20-2
Z1	21263	21-3
Z2	21264	21-3

* Part of 1771 Switch Ass'y
** Part of 1772 Switch Ass'y
*** Part of 1773 Switch Ass'y

NOTES:

1. Power supply tube 5651 (V7) should not be removed from socket when power is on.

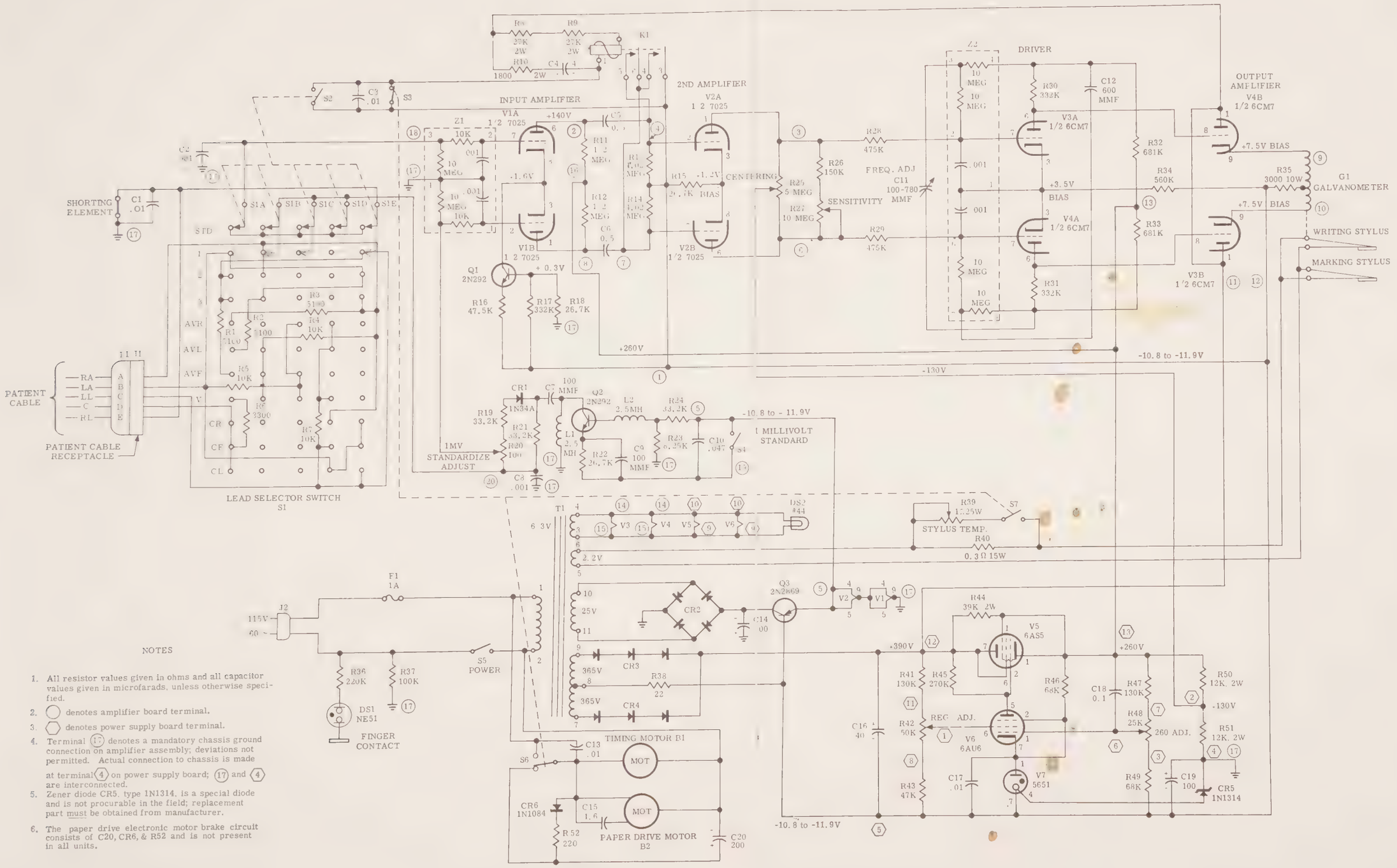


Figure 23. Schematic Wiring Diagram - 300

SECTION V
ADDENDUM

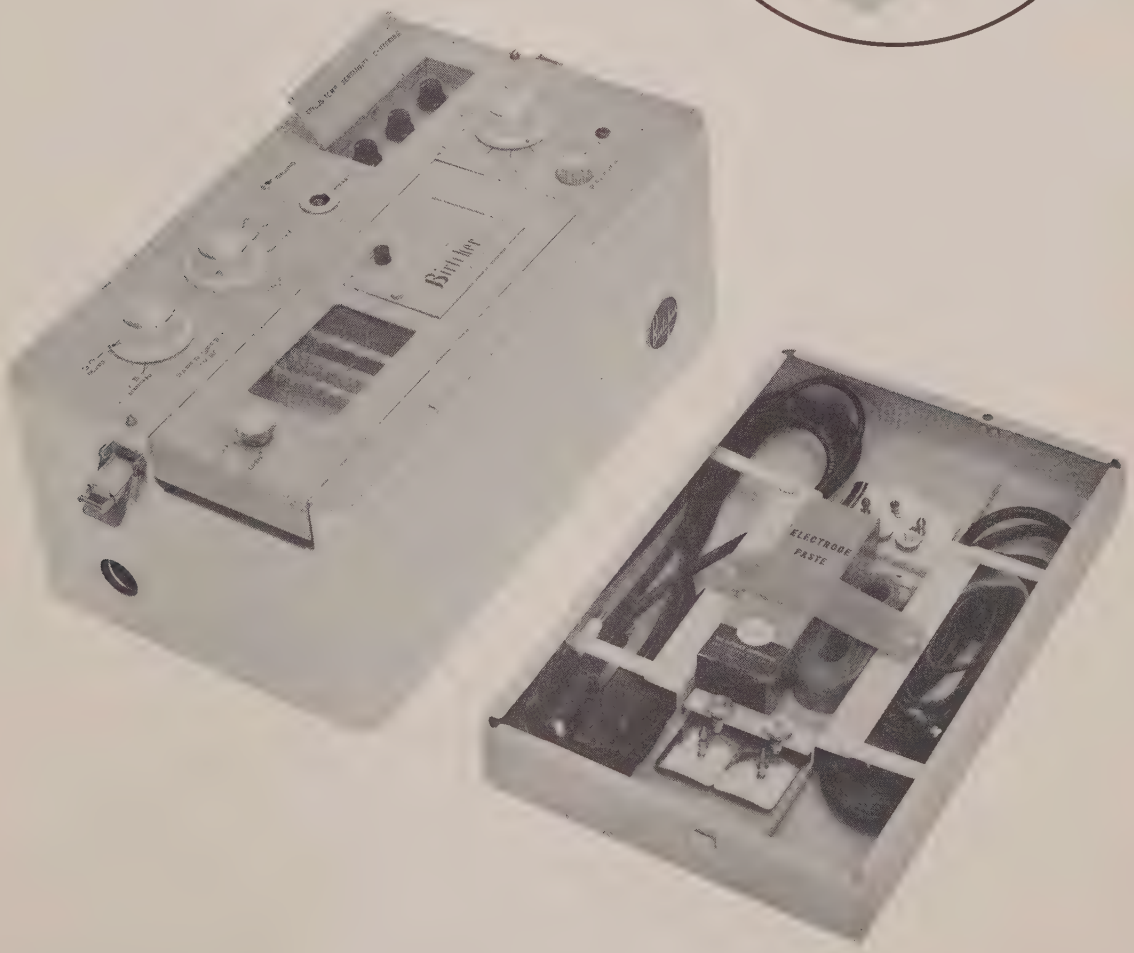
5-1 PART NUMBER CHANGES

OLD NO.	NEW NO.	FIG. & INDEX NO.
20771-1	BR1-11A	22-6
20771-2	BR5-11A	22-6
20895	21471	17-33
21206	2039	17-12
21208	2106	17-14
BB3-6	BQ-16	19-5
BB3-9	BB8-8	21-9
BB3-10	BB8-39	21-1.3
BB6-9(600uufd)	BB6-9(750uufd)	21-3.22
BB7-13	BI6-7	16-15
BB7-14	BI6-8	16-13
BB7-17	BI6-12	22-9, 18-26
BB7-18	BI6-32	22-8
BB8-15(150ufd)	BB8-15(200ufd)	18-36.1
BE1-6	21868	16-2
BE1-8	19083	16-4
BI1-38	BI3-9	18-36.2
BI1-64	BI4-11	21-4.6
BI1-65 (.2)	BI5-1 (.3)	22-1
BI1-66	BI4-12	21-6
BI1-67	BI4-13	21-7
BI1-70	BI1-95	16-16
BI1-71 (33K)	BI2-2 (33.2K)	21-3.11
BI1-72 (8.2K)	BI2-20 (8.25K)	21-3.12
BI1-74 (27K)	BI1-136 (26.7K)	21-3.14
BI1-75 (68.1K)	BI2-3 (47.5K)	21-3.15
BI1-76 (4M)	BI2-31 (4.02M)	21-3.16
BI1-77 (330K)	BI2-14 (332K)	21-3.17
BI1-82 (470K)	BI2-74 (475K)	21-3.20
BI1-83	BI3-16	21-4.3
BI1-84	BI4-17	21-4.4
BI1-85	BI3-17	21-4.5
BI1-86	BI3-18	21-4.6
BI1-88	BI3-19	21-4.7
BL2-4	2217 (See TD16116)	19-6
BL4-2 (2N301)	BL4-11(2N2869)	20-5
BL4-4	BL3-2	21-4.8
BL4-6 (1N1449)	BL2-3(1N1084)	18-36.3
BM2-9	BU10-4	19-3
BN2-3	BF2-3	16-17
BN2-5	BF2-4	22-3
DC5-6	DC5-10	20-10
DM19-1&-2	DM23-2	14-5
DM20	BE2-6	14-3
EB1-29	EB6-3	21-3.4

5-1.1. The BL1-40 (7025) electron tubes may be replaced with 12AX7 electron tubes.

PART TWO

MODEL 300R
ELECTROCARDIOGRAPH



SECTION 1A
GENERAL DESCRIPTION

1A-1. SUMMARY. Technical data for the Birtcher Model 300R Electrocardiograph is summarized as follows:

Finish: Two-tone, infrared-cured, baked enamel.

Dimensions: 16-1/4 x 9-3/4 x 9-1/2 inches high with lid (1505 Cu. In.).

Weight: 29 pounds with all accessories.

Input Power Requirements: 115 volts, 60 cycles per second
Note: Upon request unit can be supplied to operate at 115, 150, 220 or 250 volts (Additional cost).

Power Consumption: 90 watts maximum.

Grounding: Thru line cord by means of polarity indicator, or a special ground lead.

Patient Circuit: Input resistance 20 megohms each grid, differential effect.

Amplification: Cathode follower input and four stages of push pull with progressive differential effect.

1. Preamp consists of 1-12AX7 and 2-2N646, gain of 30±10% (29db)

2. D.C. amp. consists of 1-12AX7 and 2-6CM7, gain of 630±10% (56db)

Interference Rejection: .02% or better

Standardization Voltage: An electronic circuit, employing a transistor and two semiconductors which is mechanically rugged and is not subject to freezing and is permanent without depreciation.

Stabilization:

1. Circuit voltage

   a. Electronic regulated supply 1-6AS5, 1-6AU6, 1-5651 and 1 semiconductor

   b. With ±10% A.C. line voltage change stabilization to .005%

   c. A.C. ripple 40 millivolts peak to peak

2. Heater voltage for 2-12AX7 tubes

   a. Electronic regulated supply using one transistor and one semiconductor

   b. With ±10% A.C. line voltage change heater voltage stabilized to .0096%

   c. A.C. ripple 40 millivolts

Recording Method: On heat sensitive paper by heated stylus.

Total Sensitivity: Over 14MM/MV with continuous control.

Frequency Characteristic: The recorded response to 1 millivolt peak voltage variation from 1 cycle to 15 cycles per second is greater than 90% and from 15 to 40 cycles greater than 80%.

Zero Position: Adjustable ±25mm progressively and without lag.

Decay Time: At .2 second response shall not deviate more than 5%.

Recording Speeds: 25 and 50 mm per second permitting a change over during recording.

Time Marking: Automatic and continuous by means of a second stylus.

Paper Drive: Synchronous motor.

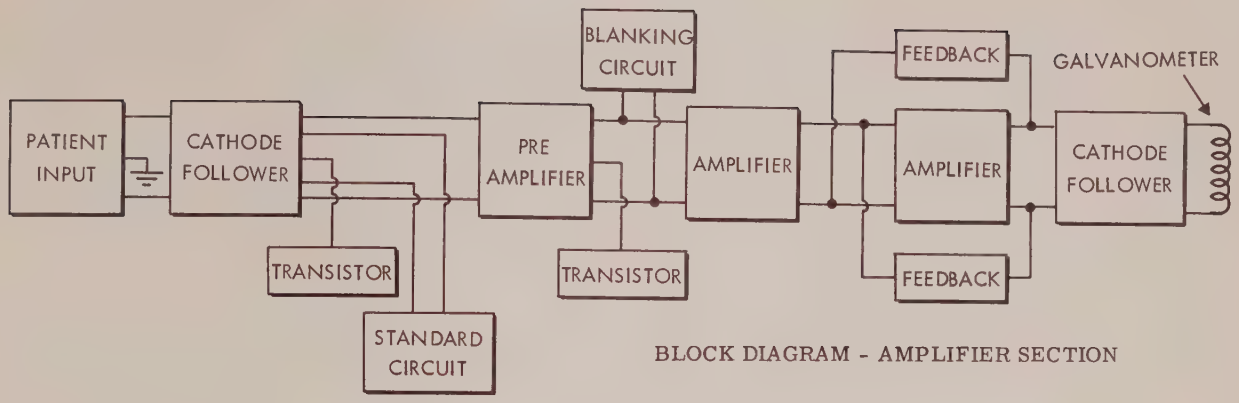
Galvanometer:

a. Sensitivity 7 ma ±.4 for 1 cm deflection at 10 cm radius.

b. Gauss 6000min.

c. Restoring force 112,000 dyne cm.

General Operation: Standard sensitivity of 1 millivolt per cm. Lead switch with stops for 1., 2., 3., AVR, AVL, AVF, V, CR, CF, and CL positions. Automatic blanking between leads except V leads.



BLOCK DIAGRAM - AMPLIFIER SECTION

SECTION 2A
GENERAL THEORY

2A-1. GENERAL. The Model 300R is a revised version of the Model 300. Examination of the circuit diagrams for these two units will reveal the fact that some circuit modifications have been made. Since it is felt that a thorough understanding of the general circuitry of the Model 300 and its operation as covered in the preceding section of this manual, section 2, General Theory, adequately explains a major portion of the total circuitry, only those aspects involved in the revision will be covered as additional circuit theory in this section.

2A-2. Certain sections of the system, and the changes involved, can be more easily understood if their description starts from the output galvanometer and progresses toward the amplifier input stage. Next the power supply unit and standardization circuit, will be considered. Minor changes such as those involving the change in a bias resistor value will not be covered in detail since these can be picked up readily from the schematic diagram. It is felt by this means, a much better explanation of the actual changes incorporated in this unit can be more clearly described.

2A-3. The output sections of the 6CM7 tubes, V3, V4, remain substantially unchanged with the exception of minor adjustments of bias values to adapt this stage to new operating potentials, however, the frequency compensating network employed as feedback in the driver sections of these two tubes has been altered. In the previous model a combination of positive and negative feedback was employed in the frequency adjusting network, however in the Model 300R the introduction of positive feedback alone is used as a means of frequency compensation. Components C9, C11, C12, R44, R45, R46, R47 in combination with C10 as an adjustable condenser comprise the components utilized in this system. Therefore adjustable condenser C10 affords means of setting frequency response characteristics for each individual unit.

2A-4. The stylus centering control R36 which appeared in the plate circuit of the second stage amplifier in the previous model now appears in the cathode circuit of this stage. This automatically allows correction for wider variation in tube characteristics.

2A-5. In order to produce a standardizing pulse with a flat horizontal top, an equalizing circuit comprised of R33, R34, R35 and C8 as a low pass time constant filter is utilized in the grid circuit of amplifier stage V2. With this system the decay curve is flat for approximately the first .1 of a second.

2A-6. Two amplifier circuit jacks are provided on the side of the cabinet, the jack coded green provides input to the D.C. amplifier system. Any input signal supplied at this jack will be amplified by the D.C. portion of the amplifier system and will subsequently record on the chart paper. The red coded jack provides A.C. coupling from the output of the second stage transistors Q2, Q3. This arrangement therefore provides for a patient selector switch and some amplification through V1 and the second stage Q2, Q3 for any external recording system.

2A-7. Transistors were used in the second stage of the amplifier system to allow a lowering of the time constant in the blanking circuit. The collector load resistances R26 and R27 in conjunction with condensers C6 and C7 allow for a very much shorter blanking time than was previously possible in the Model 300. The blanking time is of the order of .1 second maximum.

2A-8. Provision for automatic half standardization of the circuit is provided by a front panel control which places resistor R28 in parallel with the two collector load resistances R26 and R27.This effect-

ively reduces the gain of the second stage to 1/2 its preset value.

2A-9. As a result of the shortened blanking time the time constants in the blanking relay circuit have been altered. These components are C5, R29, and R30.

2A-10. The cathode follower is used as a first input stage amplifier. This affords a means of matching the low input impedance of the second stage transistors. The cathode follower amplifier is also characterized by its extremely high input impedance. This feature is a distinct advantage in the input circuit of an electrocardiograph.

2A-11. The use of transistor Q1 in the cathode return of the input amplifier stage has been described in the previous general theory for the Model 300 and it will be noted that a similar transistor is also employed, for the same reasons, in the emitter return leads of the second stage.

2A-12. The only significant change in the power supply system is the inclusion of R73. This variable potentiometer affords means of adjusting the D.C. currents in the two sections of amplifier V1 thereby affording a means of balancing the second stage transistors.

2A-13. In the previous model a variable resistor was employed as a means of presetting the output of the standardizing circuit to the required one millivolt potential. In the new unit a variable condenser C16 is now used for this adjustment. This method affords a much smoother adjustment and also improves the long term stability of the circuit. The output of this standardizing circuit is fed to junctions of the cathode follower load resistance and the standardizing potential appears across R13 and R14 in the cathode circuit as a push-pull signal.

2A-14. An electronic brake has been added to the paper drive motor. Its function is to prevent paper coasting when the motor is turned off. Rectifier 1N1449, resistor R58 and condenser C20 comprise this circuit. Switching is arranged so that condenser C20 is being charged through rectifier 1N1449 and resistor R58 in series during the period of time that the paper is in motion, however at the instant that the paper drive is turned off condenser C20 discharges reverse current through the motor windings in order to provide for instant stopping of all paper motion.

2A-15. With the introduction of the new tubular stylus it became necessary to revise the stylus temperature control adjustment circuit, components in this circuit are S6C, R62 and R63.

SECTION 3A
MAINTENANCE

3A-1. STYLUS PRESSURE ADJUSTMENT. The Model 300R is supplied with a tubular type stylus, Catalog No. 310, which is adjusted in the same manner as indicated on Part One, Page 11, Paragraph 3-10. Examples of the various results of different stylus pressures are shown below.

3A-2. If efforts to correctly adjust the stylus pressure do not produce a clear, well defined base line, it is possible the tubular writing surface of the stylii may have become dirty from deposits of chart paper wax or other deposits - inspect the stylii and if dirty, clean by gently scraping with a sharp edged instrument or with number 00 (or finer) sand paper only. Steel wool should never be used. It is not necessary to remove either stylus to clean them.

3A-3. A well-defined dense base line should be obtained after adjustment and cleaning, however, if the base line is still not satisfactory, it is necessary to replace the stylus.

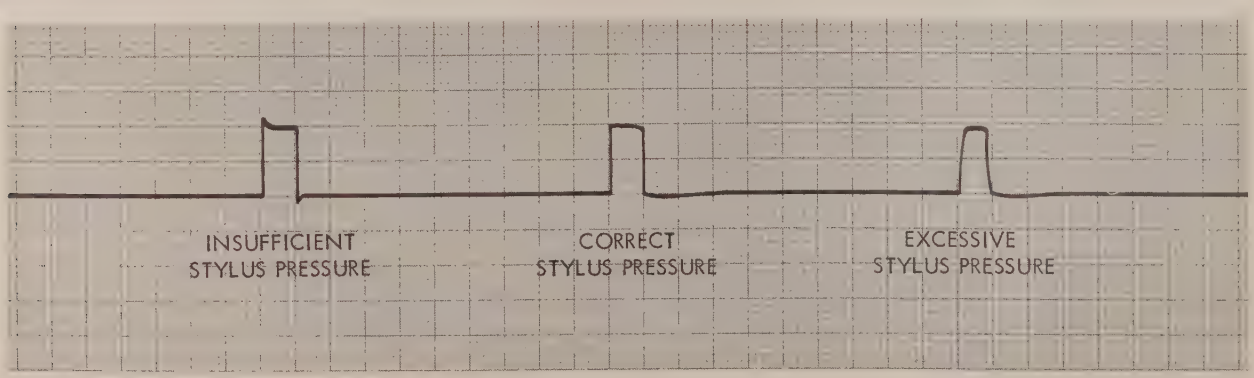


TABLE 1A. TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ECG test recording has base line only, no standardization pulse; CENTERING control has no effect (causes no displacement of stylus), paper drive motor functions normally.	No B-plus voltage.	Check R61.
	No regulated filament supply.	Check Q5 and CR2.
	Defective V2.	Check C22.
	No B-minus voltage.	Check C26 and CR6. Replace V2.
Same as preceding symptom except CENTERING control has normal effect.	Q1 defective; check S2, S6B, S6C S6D, C3, Q2, Q3, Q4, Q5, and Q6.	Replace Q1. Replace faulty part.
	Defective V1.	Replace V1.
A-c interference appears on trace in standardizing position.	V1 or V2 defective.	Replace V1 or V2.
	Check C19.	Replace C19.
	Q1 defective.	Replace Q1.
	S1 defective.	Replace S1.
	B- or fil. supply not regulating.	Replace V5, V6, V7, C22.
	Line polarity incorrect.	Reverse power plug.
Trace made by writing and/or marking stylus appears weak and is not sharply defined; STYLUS TEMP. may require excessive clockwise rotation.	Either stylus may be bent, may have insufficient pressure, may be coated with wax, or may be worn out.	Repair stylus, burn off wax coating, readjust pressure, or replace as required. (See paragraphs 3-9, 3-10, and 3-19.)
	Check S6C.	Replace or adjust.
Fuse F1 blows when PAPER DRIVE button is depressed.	Paper drive motor B2, timing motor B1, or motor capacitor C18 are shorted.	Replace defective component.
	Defective CR2, C22, C23.	Replace defective component.
Standardization pulse not preset, otherwise operation is normal.	One-millivolt standardization circuit not functioning.	Check for r-f output with oscilloscope across R57 (with 1 MILLIVOLT STANDARD button depressed). Check continuity of S7 (power off). Check (by replacement method) CR1 and Q5.
Writing stylus deflects to maximum position when ECG is turned on; CENTERING control has no effect.	V2, V3 or V4 defective.	Replace defective tube.
	Capacitor C6 or C7 leaky.	Replace defective capacitor.
	Galvanometer coil open, or one half shorted to ground.	Check with ohmmeter and replace galvanometer (paragraph 3-21, page 17-part 1).
	CENTERING control R36. defective.	Replace R36.
	Plate resistors R49 or R50 open.	Replace R49 or R50.

TABLE 2A. TUBE SOCKET VOLTAGE MEASUREMENTS TO GROUND
Stylus Centered on Paper
Line Voltage 115 Volts

Tube socket pins	1	2	3	4	5	6	7	8	9
12AX7 (V1)	190	0	1.7	5.7±5%	5.7±5%	190	0	1.7	0
12AX7 (V2)	100	0	1	11.4±5%	11.4±5%	100	0	170	187
6CM7 (V3)	390	0	115	6.3AC	6.3AC	170	105	170	187
6CM7 (V4)	390	0	115	6.3AC	6.3AC	170	105	170	187

TABLE 3A. TUBE SOCKET RESISTANCE MEASUREMENTS
To Ground

Tube socket pins	1	2	3	4	5	6	7	8	9
12AX7 (V1)	17K	51K	15K	4 ohm	4 ohm	17K	51K	15K	0
12AX7 (V2)	.75K	3.3M	44.2K	4 ohm	4 ohm	.75M	3.3M	44.2K	4 ohm
6CM7 (V3)	50K	0	.976M	0	0	1M	1.5M	1M	6.5K
6CM7 (V4)	50K	0	.976M	0	0	1M	1.5M	1M	6.5K

TABLE 4A. MEASUREMENTS TO GROUND

Transistor	C	B	E
2N292 (Q1)	-8	-10.8	11
2N646 (Q2)	8	1.7	1.6
2N646 (Q3)	8	1.7	1.6

Transistor	C	B	E
2N292 (Q4)	1.5	-.9	-.9
2N292 (Q5)	0	-2.2	-2
2N250 (Q6)	-23	-11.4±5%	-11.2±5%

SECTION 4A
PARTS LIST

4-1. GENERAL. Excluding miscellaneous common hardware, all assemblies and replacement parts for the Birtcher Model 300R Electrocardiograph are listed and illustrated in this section.

4-2. Major assemblies are listed and each assembly broken down to its component parts. Each assembly or part that is illustrated is referenced to the illustration by figure and index number. For example, 6-6 in the "FIG. INDEX NO." column means the item is shown in figure 6, by index number 6.

4-3. Reference designations on items that appear in the schematic diagram will be found in the "REF. DESIG." column of this parts list.

4-4. In the price column, the designation "CAT.", means that item should be priced from the current Standard Catalog Price List.

4-5. All parts and assemblies should be procured from the Birtcher Corporation, 4371 Valley Blvd., Los Angeles 32, California. Replacement parts should be requisitioned by part number, nomenclature and quantity described in addition to the Model and Serial number of equipment.

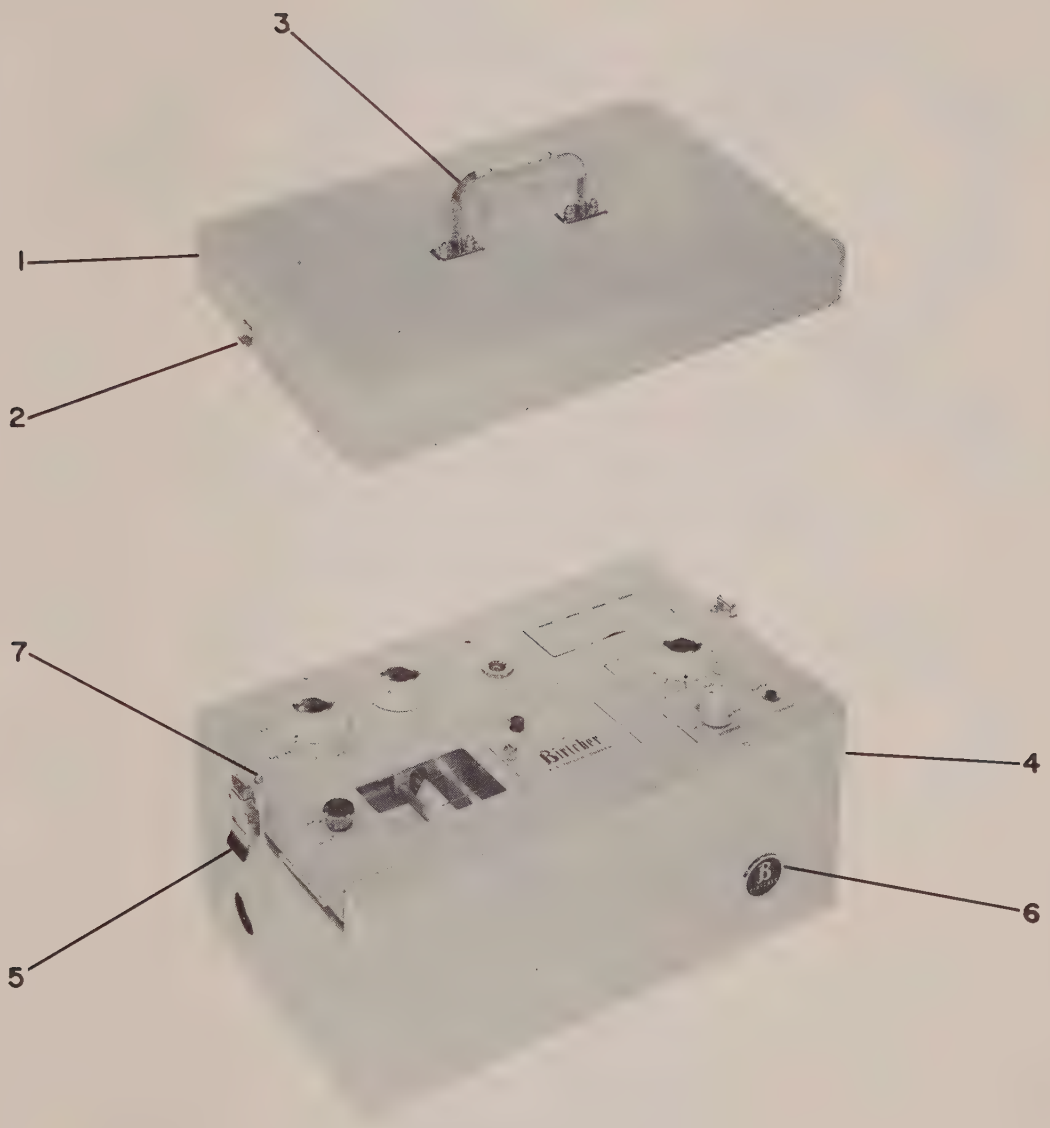


Figure 1A. Major Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
1A-	300R	MAJOR ASSEMBLY		1	Ref.
-1	21192	COVER, Cabinet		1	20.00
-2	DM19-2	STRIKER, Cover latch		2	.75
-3	DM20	HANDLE, Carrying		1	3.00
-4	1780-1	BODY, Cabinet		1	30.00
-5	DM19-1	LATCH, Cabinet cover		2	1.50
-6	20058	EMBLEM (Exchange only)		1	2.50
-7	19005-82	SPACER - Cover positioning screw		2	.10

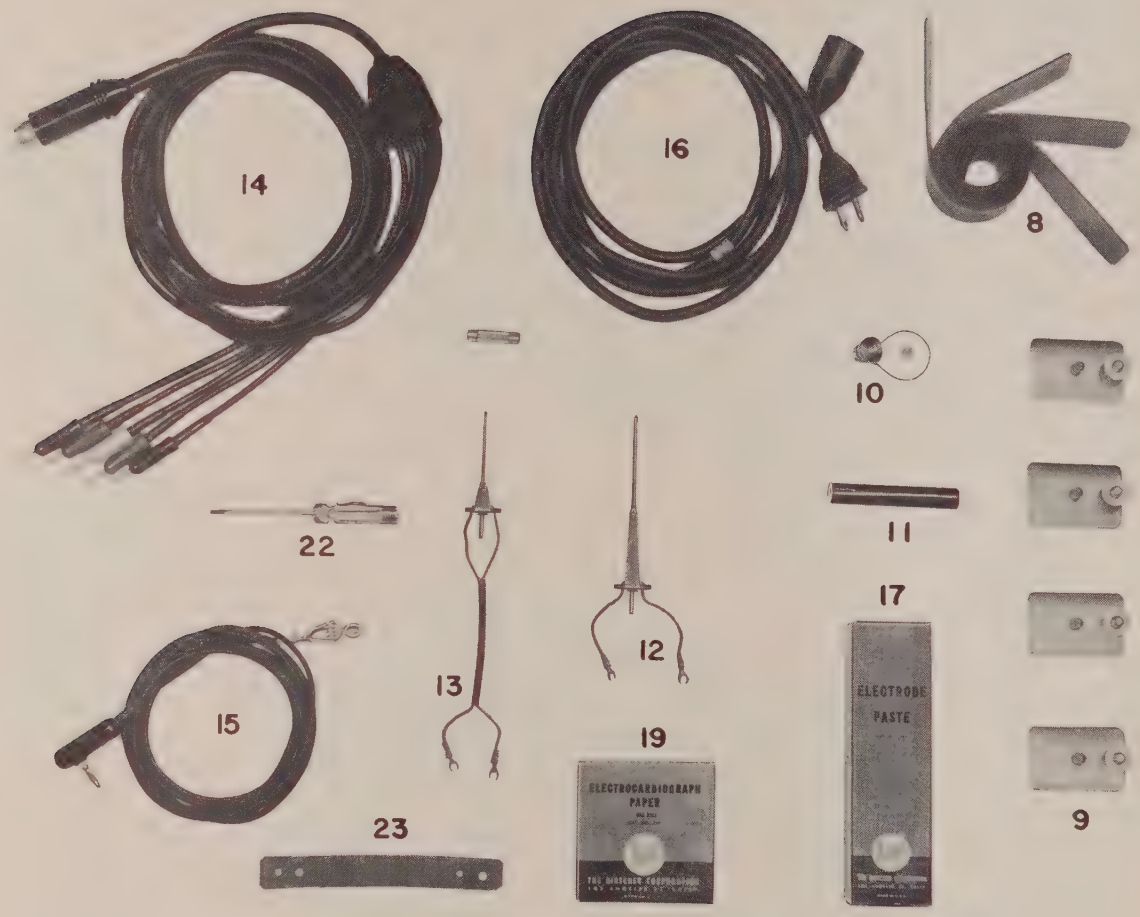


Figure 1A. Major Assembly (Cont.)

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
1A-	300R	MAJOR ASSEMBLY (Accessories)		-	Cat.
-8	243	STRAP, Electrode		4	Cat.
-9	301	ELECTRODE, Extremity		4	Cat.
-10	302	ELECTRODE, Chest		1	Cat.
-11	303	HANDLE, Chest electrode		1	Cat.
-12	310	* STYLUS, Writing		1	Cat.
-13	311	* STYLUS, Marking		1	Cat.
-14	315	CABLE, Patient electrode		1	Cat.
-15	317	CORD, Ground connection		1	Cat.
-16	318	CORD, A.C. line		1	Cat.
-17	347	PASTE, Electrode		1	Cat.
-18	379-1	** RULE and CALCULATOR		1	Cat.
-19	350-N	CHART, Paper roll		2	Cat.
-20	CB8-2	** SCALE		1	Cat.
-21	CB8-1	** COVER, Plastic		1	Cat.
-22	DJ3-1	DRIVER, Screw		1	Cat.
-23	21259	STRAP, Accessory retaining		1	Cat.

* One in unit.
** Not shown.
All accessories are furnished as part of initial equipment.

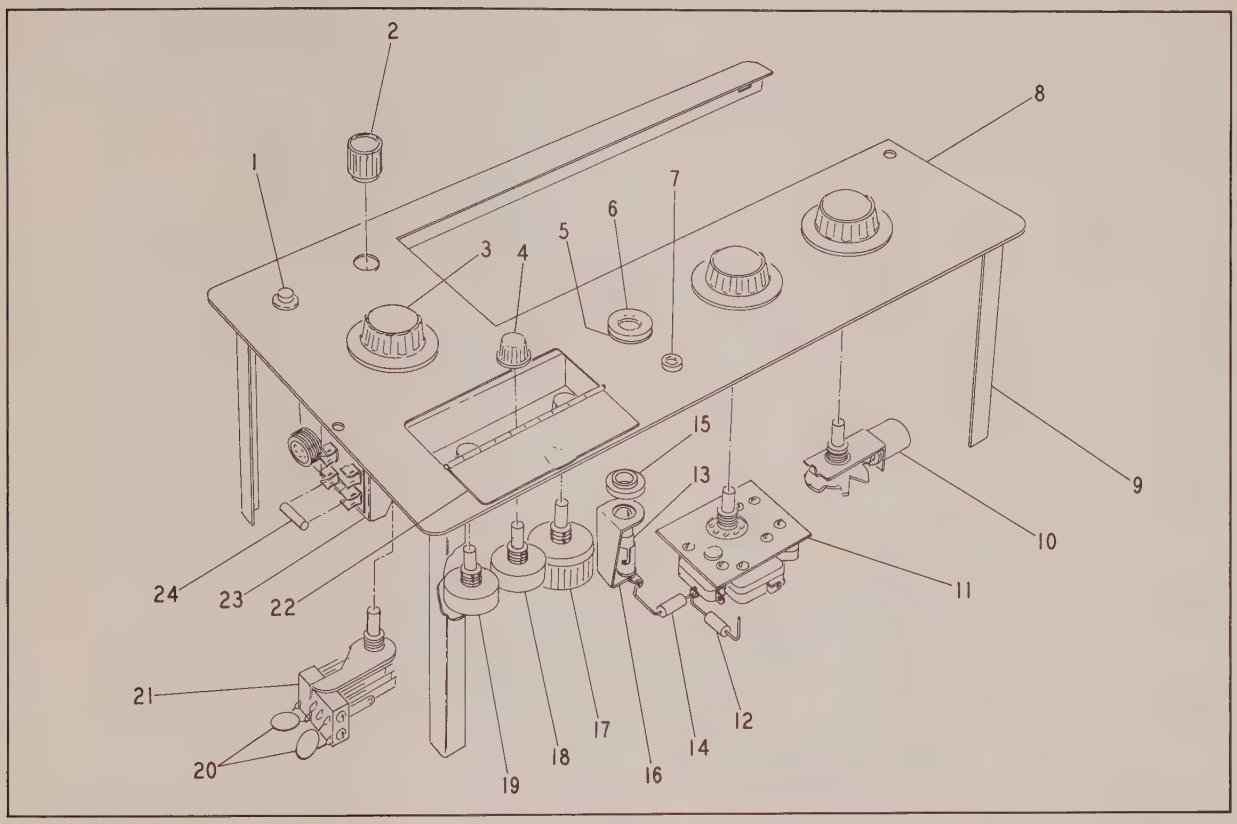


Figure 2A. Panel Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
2A-	.....	PANEL ASSEMBLY		1	Ref.
-1	BK4-8	SWITCH, Push button	S7	1	3.50
-2	BE1-7	KNOB		1	1.00
-3	BE1-6	KNOB		3	.90
-4	BE1-8	KNOB		3	.75
-5	19260-93	WASHER, Insulator			.10
-6	21158	PLATE, Polarity touch		1	1.50
-7	19364-1	JACK, Ground	J3	1	.25
-8	1765-1	PANEL ASSEMBLY		1	25.00
-9	21120	ANGLE, Corner support		3	.50
-10	1797	SWITCH, Speed		1	3.00
-11	1894	SWITCH, Power	S3, S4, S5	1	15.00
-12	BI1-69	RESISTOR, 100K-1/2W	R59	1	.20
-13	BF1-10	LAMP, Neon	I1	1	.75
-14	BI1-80	RESISTOR, 220K-1/2W	R60	1	.75
-15	21159	WASHER, Insulator shoulder		1	.35
-16	BN2-3	SOCKET, Neon lamp		1	.50
-17	BB7-13	POTENTIOMETER, 1 ohm-25W.	R63	1	7.50
-18	BB7-14	POTENTIOMETER, 10 meg.	R40	1	1.00
-19	BB7-36	POTENTIOMETER, 1500 ohm	R36	1	1.50
-20	BB6-8	CAPACITOR, .01 MFD.-600V.	C2, C21	2	.20
-21	BK4-7	SWITCH, Chart drive	S6A,B,C,D	1	7.50
-22	21094	LID, Control cover		1	7.50
-23	1773-1	SWITCH, Lead selector	S1	1	26.50
-24	21257	JUMPER, Fuse		1	.20

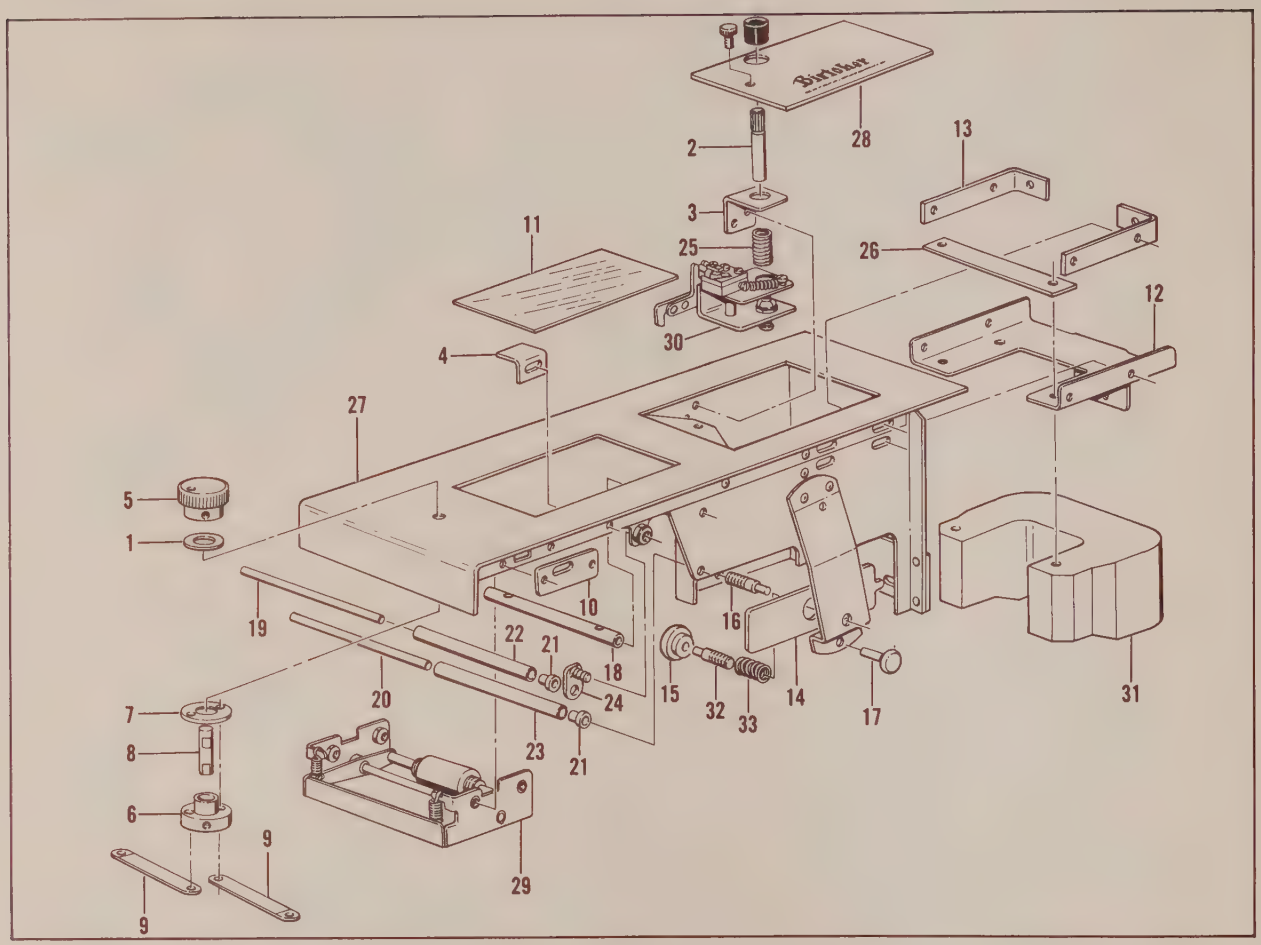


Figure 3A. Chart Door Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
3A-	1764	CHART DOOR ASSEMBLY		1	Ref.
-1	19260-30	WASHER, Felt		1	$ .10
-2	21185	SHAFT, Marker		1	.30
-3	21186	ANGLE, Marker shaft		1	.20
-4	21195	CLIP, Window		2	.25
-5	21196	KNOB, Latch		1	2.00
-6	21197	DISC, Cam		1	1.25
-7	21198	DISC, Spacer		1	.75
-8	21233	SHAFT, Latch		1	.20
-9	21200	ROD, Latch		2	.50
-10	21201	PLATE, Latch adj.		2	.50
-11	21203	WINDOW		1	1.25
-12	21206	BRACKET, Galvanometer		1	3.50
-13	21207	BRACKET, Hinge		2	1.25
-14	21208	PLATE, Roll guide		2	.45
-15	21210	BUTTON, Pivot		2	1.00
-16	21211	STUD, Pivot		1	.90
-17	21213	KNOB, Paper release		1	1.25
-18	21214	ROD, Stylus restrain		1	.75
-19	21216	SHAFT, Adj. roller		1	.20
-20	21217	SHAFT, Guide roller		1	.25
-21	21218	BUSHING, Roller end		4	.15

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
3A-	1764	CHART DOOR ASSEMBLY (Cont.)		1	Ref.
-22	21219	ROLLER, Adj.		1	.50
-23	21220	ROLLER, Guide		1	.30
-24	21221	SCREW, Adj.		1	.25
-25	21225	SPRING, Marker shaft		1	.10
-26	21234	GUARD, Terminal		1	.10
-27	1760	FRAME		1	20.00
-28	1671-1	PLATE, Access		1	5.00
-29	1762	BOX, Pressure roller		1	10.00
-30	1776	MARKER ASSEMBLY		1	13.50
-31	1791	GALVANOMETER		1	175.00
-32	21211-1	STUD, Pivot		1	.90
-33	20895	SPRING, Stud		1	.20
4A-	.....	CHASSIS ASSEMBLY		1	Ref.
-1	1777	BOARD, Resistor		1	15.00
	BI2-18	RESISTOR, 1200 ohm-1/4W, 1%	R13, R14	2	.75
	BI2-6	RESISTOR, 681 ohm-1/4W, 1%	R17	1	.75
	BI2-23	RESISTOR, 10K-1/4W, 1%	R18	1	.75
	BI2-4	RESISTOR, 1500 ohm-1/4W, 1%	R16	1	.75
	BL4-1	TRANSISTOR, 2N292	Q1	1	5.50
	21536	INSULATOR, Resistor board			.20
-2	DE2-1	STRIP, Terminal			.20
-3	21237-1	INSULATOR, Terminal			.20
-4	21182	CAM, Timing motor		1	.50
-5	BQ5	MOTOR, Timing	B1	1	12.00
	BQ8	MOTOR, Timing (50 cycle)			22.50
-6	BF1-9	LAMP, G.E. No. 44	I2	1	.25
-7	BN2-5	SOCKET, Chart lamp		1	.35
-8	19013-37	SPACER, Socket mounting		2	.30
-9	21156	SPACER, Gear box mounting		4	.20
-10	21122-1	PARTITION, Left		1	2.50
-11	1784	BOX, Gear		1	33.00
-12	BB2-15	CAPACITOR, .1 MFD.-400V.	C19	1	.85
-13	1851	BRAKE, Electronic motor		1	9.50
	BB8-15	CAPACITOR, 150 MFD.-200V.	C20	1	2.50
	BI1-38	RESISTOR, 220 ohm-1W, 10%	R58	1	.50
	BL4-6	RECTIFIER, 1N1449	CR5	1	5.00
-14	21194	SADDLE, Chart		1	1.75
-15	21123	BRACKET, A.C.		1	1.00
-16	BM2-9	RECEPTACLE, 110V.	J2	1	2.75
-17	BS1-2	FUSE, 1 Amp. (Cat. No. 319)	F1	1	Cat.
-18	1803	MOUNT, Line fuse		1	1.25
	21162	INSULATOR, Fuse mount		1	.15
-19	20771-1	TRANSFORMER, Power	T1	1	40.00
	20771-2	TRANSFORMER, Special voltage			Ref.
-20	21202	BLOCK, Side		2	.75
-21	BB8-8	CAPACITOR, 100 MFD.	C26	1	1.35
-22	BI1-90	RESISTOR, 22 ohm-1/2W.	R61	1	.20
-23	BI5-2	RESISTOR, 4K-10W.	R53	1	1.75
-24	21167	BRACKET, Rectifier		1	.10
-25	BL2-1	RECTIFIER, Selenium	CR3, CR4	6	1.50
-26	1787-1	BOARD, Power supply		1	45.00
-27	21166	BRACKET, Rectifier		2	.15
-28	BI5-1	RESISTOR, .3 ohm-15W.	R62	1	3.00
-29	19260-76	WASHER, Shock mount		1	.10
-30	21138-1	BRACKET, Potentiometer		1	1.00
-31	1783-1	CHASSIS		1	12.50
-32	BB7-18	POTENTIOMETER, 50K-2W.	R66	1	4.50

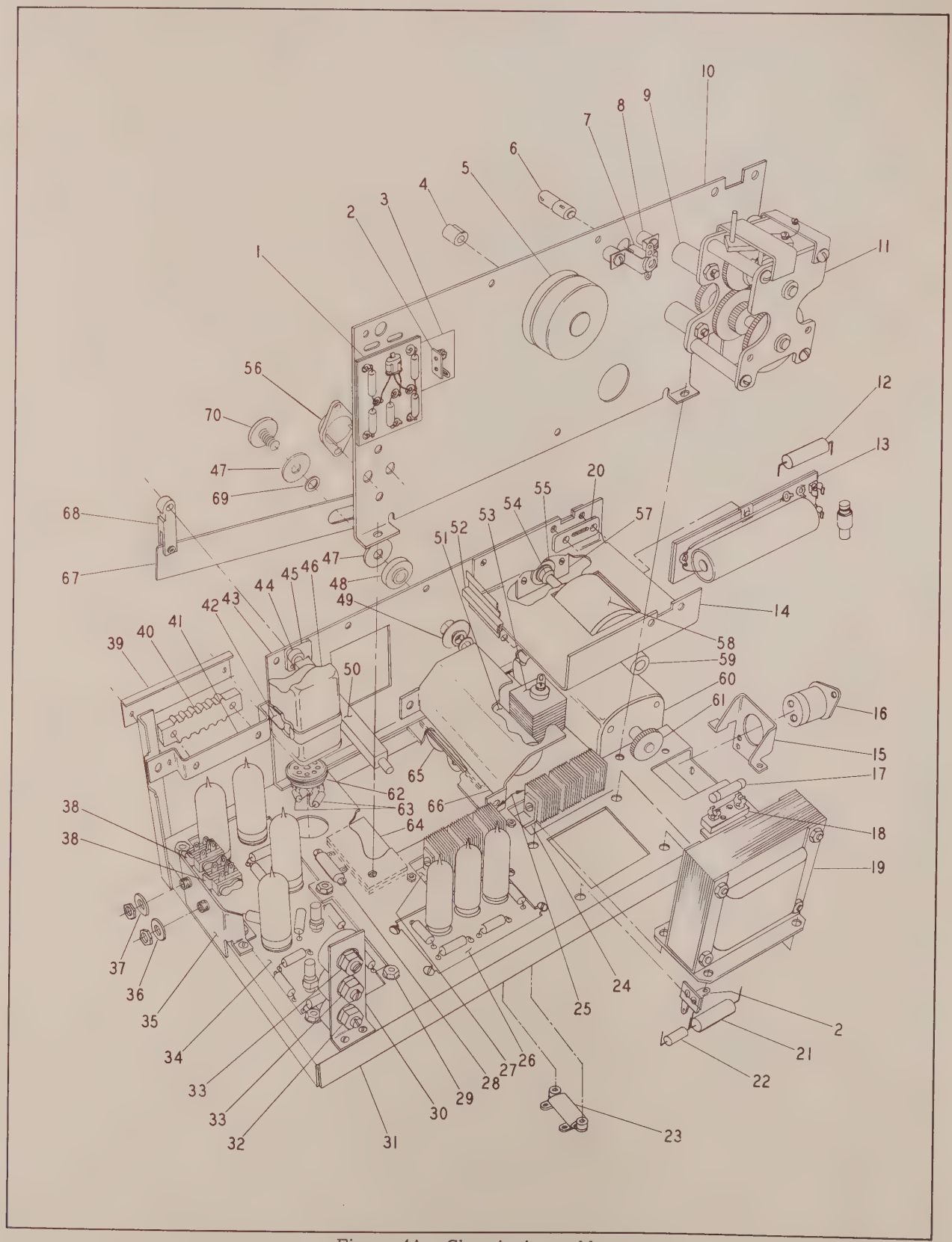


Figure 4A. Chassis Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
4A-	.....	CHASSIS ASSEMBLY (Cont.)		1	Ref.
-33	BB7-17	POTENTIOMETER, 25K-2W	R71, R73	2	4.50
-34	1786-1	BOARD, Amplifier		1	120.00
-35	21480	BRACKET, Jack mounting		1	.50
-36	19260-105	WASHER, Green		1	.20
-37	19260-104	WASHER, Red		1	.20
-38	BM3-6	JACK, Input - output		2	2.50
-39	21481	COVER, Terminal		1	.25
-40	DE2-7	BOARD, Terminal		1	1.50
-41	21343	BRACKET, Terminal		1	.40
-42	DC5-10	CLAMP, Relay		1	1.50
-43	21121-1	PARTITION, Right		1	2.50
-44	21127	COLLAR, Hinge shaft		2	.35
-45	21125	BEARING, Hinge		2	.50
-46	BJ1-5	RELAY	K1	1	30.00
-47	19260-94	WASHER, Nylon friction		2	.20
-48	21131	BUSHING, Friction		1	.55
-49	19260-95	WASHER, Tension bolt		1	.10
-50	21126	SHAFT, Hinge		1	1.75
-51	BB3-6	CAPACITOR, 1.6 MFD.	C18	1	7.50
-52	1806	BAR, Writing		1	3.50
-53	BL2-4	RECTIFIER, Selenium bridge	CR2	1	4.20
	19005-11	SPACER, Rectifier mounting		1	.25
-54	21341	COLLAR, Drive drum		1	.30
-55	SB2-1	BEARINGS, Ball		1	.75
-56	BL4-11	TRANSISTOR, 2N250	Q6	1	7.50
		WASHERS, Transistor mounting		2	Ref.
		INSULATOR, Transistor		1	Ref.
-57	21134-1	PLATE, Ball bearing		1	.30
-58	1775	DRUM, Chart drive		1	6.75
-59	21157	COUPLING, Gear box		1	.50
-60	BQ6	MOTOR, Chart drive	B2	1	90.00
	BQ7	MOTOR, 60 cycle			Ref.
	21165	BRACKET, Motor mounting		1	.50
	21165-1	BRACKET, Motor mounting		1	.50
	19005-85	SPACER, Motor mounting		2	.15
-61	21154	GEAR, Drive motor		1	2.00
-62	BN-14	SOCKET, 8 pin		1	.50
-63	BI2-10	RESISTOR, 3.3 meg.	R31, R32	2	1.00
-64	1895	BOARD, Capacitor			5.75
	BB2-14	CAPACITOR, .47 MFD.	C6, C7	2	3.75
	21476	INSULATOR, Capacitor board			.25
-65	1785-1	BOARD, Capacitor		1	8.50
	BB8-3	CONDENSER, 40 MFD.-450V.	C23	1	2.50
	BB3-10	CONDENSER, 100 MFD.-50V.	C5	1	1.50
	BB8-19	CONDENSER, 150 MFD.-50V.	C22	1	1.50
	BI3-3	RESISTOR, 100 ohm-1W., 5%	R29	1	.35
	BI3-2	RESISTOR, 470 ohm-1W., 5%	R30	1	.35
	21160-1	INSULATOR, Capacitor board		1	.30
-66	21260	GUARD, Condenser		1	.50
-67	21129	BAR, Friction		1	.75
-68	21128	ARM		1	.35
-69	19260-99	WASHER, Nylon		1	.25
-70	21130	STUD, Tension		1	.75

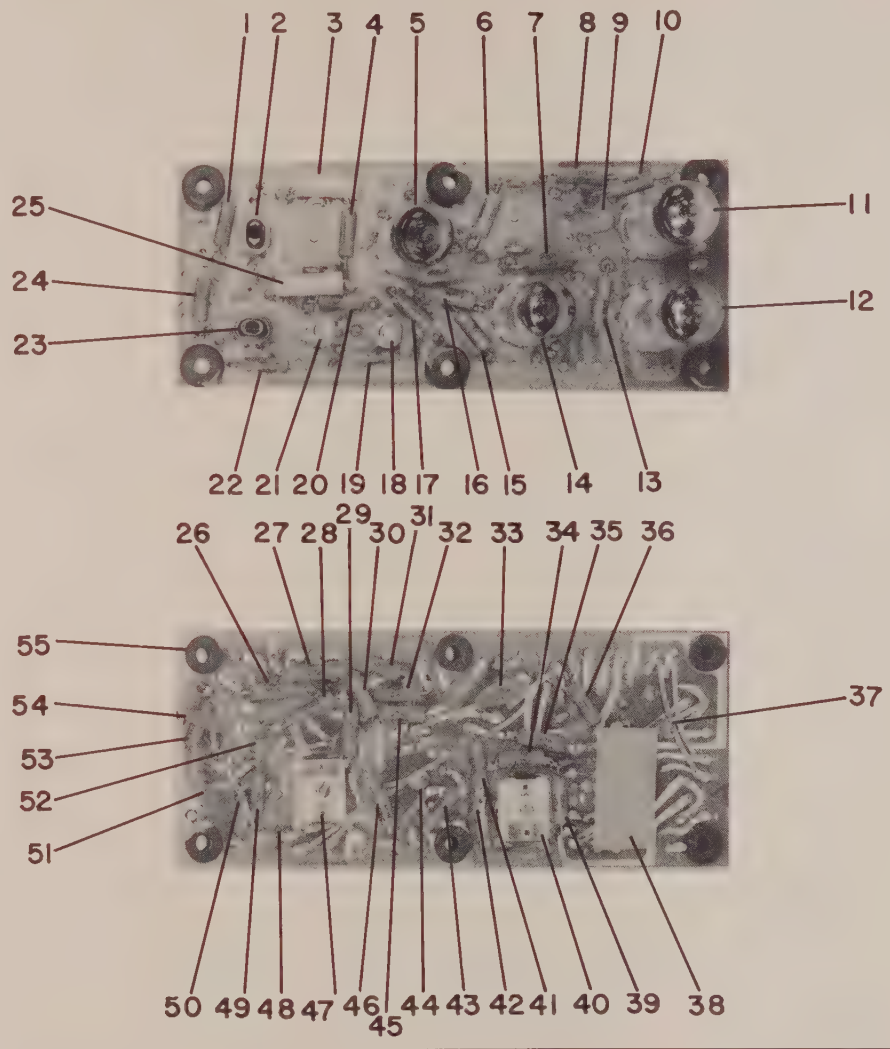


Figure 5A. Amplifier Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
5A-	1786-1	AMPLIFIER ASSEMBLY		1	120.00
-1	BI2-30	RESISTOR, 44.2K ohm-1/4W. 1%	R37	1	1.00
-2	BL4-1	TRANSISTOR, 2N292	Q5	2	5.00
-3	BC1-8	COIL, R.F. choke	L2	2	1.75
-4	BI2-20	RESISTOR, 8.2K ohm 1%	R55	2	.85
-5	BL1-40	TUBE, 12AX7 or 7025	V1	2	Cat.
-6	BI2-7	RESISTOR, 681K ohm 1%	R52	4	.85
-7	BI2-7	RESISTOR, 681K ohm 1%	R51	4	.85
-8	BI2-14	RESISTOR, 332K ohm 1%	R50	2	.85
-9	BB6-9	CAPACITOR, 750 MMFD.	C9	1	.25
-10	BI2-13	RESISTOR, 976K ohm 1%	R48	1	1.00
-11	BL1-39	TUBE, 6CM7	V4	2	Cat.
-12	BL1-39	TUBE, 6CM7	V3	2	Cat.
-13	BI2-17	RESISTOR, 150K ohm 1%	R41	1	1.00
-14	BL1-40	TUBE, 12AX7 or 7025	V2	2	Cat.
-15	BI2-15	RESISTOR, 221K ohm 1%	R34	2	.85

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
5A-	.....	AMPLIFIER ASSEMBLY (Cont.)		1	Ref.
-16	BI2-10	RESISTOR, 3.3M ohm 1%	R35	1	1.00
-17	BI2-28	RESISTOR, 180 ohm-1/4W. 1%	R19	2	1.00
-18	BL4-14	TRANSISTOR, 2N646	Q2	2	5.50
-19	BI2-11	RESISTOR, 18K ohm 1%	R27	2	.85
-20	BI2-22	RESISTOR, 51K ohm 1%	R12	5	.85
-21	BL4-14	TRANSISTOR, 2N646	Q3	2	5.50
-22	BI2-20	RESISTOR, 8.2K ohm 1%	R23	2	.85
-23	BL4-1	TRANSISTOR, 2N292	Q4	2	5.00
-24	BI2-22	RESISTOR, 51K ohm 1%	R24	5	.85
-25	BC1-8	COIL, R.F. choke	L3	2	1.75
-26	BI2-22	RESISTOR, 51K ohm 1%	R15	5	.85
-27	BI2-28	RESISTOR, 180 ohm-1/4W 1%	R20	2	1.00
-28	BI2-19	RESISTOR, 27K ohm 1%	R57	2	.85
-29	BI2-29	RESISTOR, 82K ohm-1/4W 1%	R22	2	.85
-30	BI2-29	RESISTOR, 82K ohm-1/4W 1%	R21	2	.85
-31	BI2-2	RESISTOR, 33K ohm 1%	R56	1	.85
-32	BI2-11	RESISTOR, 18K ohm 1%	R26	2	.85
-33	BB6-8	CAPACITOR, .01 MFD.	C8	1	.20
-34	BI2-12	RESISTOR, 1M 1%	R39	2	1.00
-35	BI2-7	RESISTOR, 681K ohm 1%	R42	4	.85
-36	BI2-15	RESISTOR, 681K ohm 1%	R33	2	.85
-37	BI2-14	RESISTOR, 332K ohm 1%	R49	2	.85
-38	21264	NETWORK, Printed	Z1	1	2.50
-39	BI2-7	RESISTOR, 681K ohm 1%	R43	4	.85
-40	BB4-4	CAPACITOR, 100-780 MMFD. (Var.)	C10	2	1.50
-41	BI2-12	RESISTOR, 1M 1%	R38	2	1.00
-42	BB6-6	CAPACITOR, 100MMFD. 10%	C4	6	.25
-43	BI2-22	RESISTOR, 51K ohm 1%	R10	5	.85
-44	BB6-6	CAPACITOR, 100MMFD. 10%	C3	6	.25
-45	BI2-22	RESISTOR, 51K ohm 1%	R11	5	.85
-46	BI2-19	RESISTOR, 27K ohm 1%	R28	2	.85
-47	BB4-4	CAPACITOR, 100-780 MMFD. (Var.)	C16	2	1.50
-48	BB6-6	CAPACITOR, 100 MMFD. 10%	C15	6	.25
-49	BI2-23	RESISTOR, 10K ohm-1/4W 1%	R54	1	.85
-50	BL4-15	DIODE, 1N115	CR1	1	3.00
-51	BB6-6	CAPACITOR, 100MMFD. 10%	C14	6	.25
-52	BB6-6	CAPACITOR, 100MMFD. 10%	C17	6	.25
-53	BI2-9	RESISTOR, 2.74K ohm 1%	R25	1	1.00
-54	BB6-6	CAPACITOR, 100 MMFD 10%	C13	6	.25
-55	EB1-29	MOUNT, Shock		6	.25

NOTE: See figure 6A, page 15A for power supply assembly parts list.

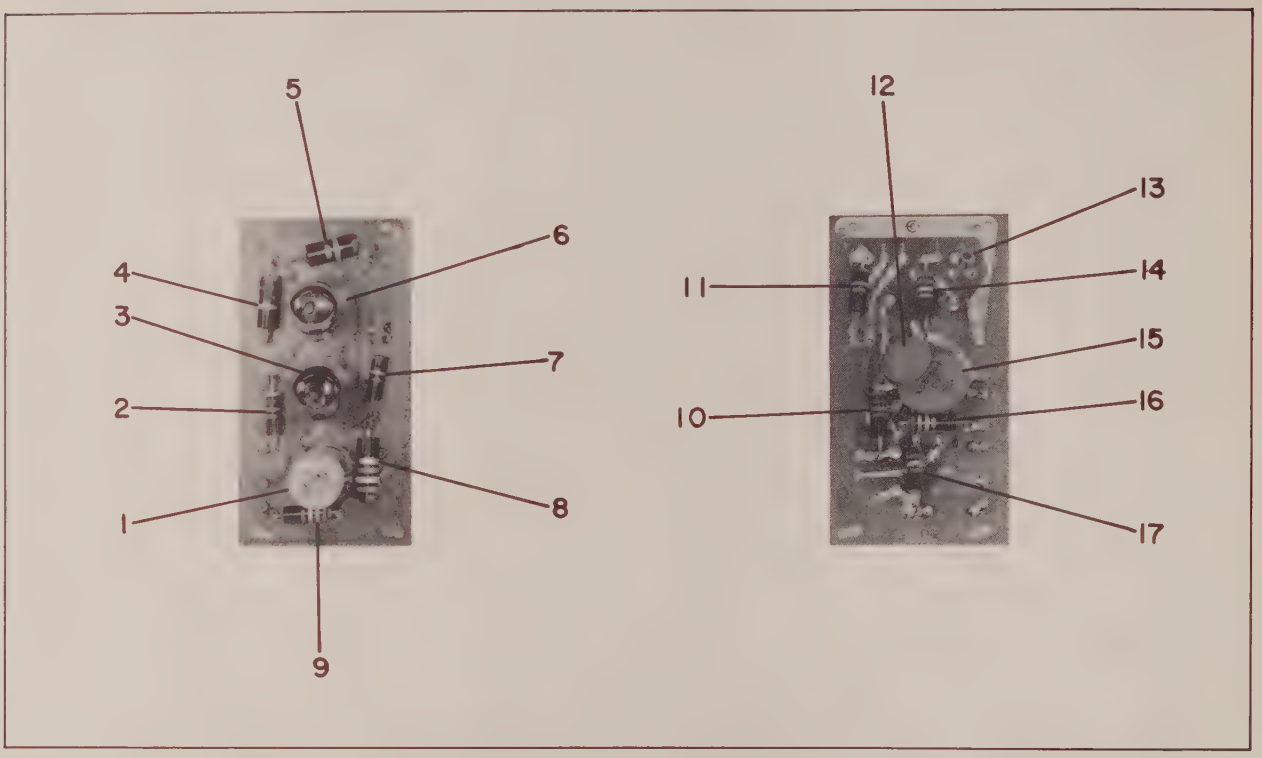


Figure 6A. Power Supply Assembly

FIG. & INDEX NO.	PART NUMBER	NOMENCLATURE	REF. DESIG.	QTY.	PRICE (EACH)
6A-	1787-1	POWER SUPPLY ASSEMBLY		1	45.00
-1	BL1-38	TUBE, 6AS5	V5	1	Cat.
-2	BI1-85	RESISTOR, 47K ohm 1W	R67	1	.50
-3	BL1-37	TUBE, 6AU6	V6	1	Cat.
-4	BI1-67	RESISTOR, 10K ohm 2W	R77	1	.35
-5	BI1-113	RESISTOR, 10K ohm 2W	R76	1	.45
-6	BL1-36	TUBE, 5651	V7	1	Cat.
-7	BI3-4	RESISTOR, 10K ohm 1W	R74	2	.35
-8	BI1-64	RESISTOR, 39K ohm 2W	R68	1	.30
-9	BI1-83	RESISTOR, 130K ohm 1W	R65	2	.35
-10	BI1-88	RESISTOR, 68K ohm 1W	R69	2	.35
-11	BI3-4	RESISTOR, 10K ohm 1W	R75	2	.35
-12	BB6-8	CAPACITOR, .01 MFD	C24	1	.20
-13	BI-188	RESISTOR, 68K ohm 1W	R72	2	.35
-14	BL4-4	DIODE, 1N1314 Zener	CR6	1	22.00
-15	BB6-15	CAPACITOR, .05 MFD. -500V.	C25	2	.50
-16	BI1-83	RESISTOR, 130K ohm 1W	R70	1	.35
-17	BI1-86	RESISTOR, 270K ohm 1W	R64	1	.35

CROSS REFERENCE
Wiring diagram-Parts list

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
B1	BQ5	4A-5
B2	BQ6	4A-60
C1	BB6-8	2A-23
C2	BB6-8	2A-20
C3	BB6-6	5A-44
C4	BB6-6	5A-42
C5	BB3-10	4A-65
C6	BB2-14	4A-64
C7	BB2-14	4A-64
C8	BB6-8	5A-33
C9	BB6-9	5A-9
C10	BB4-4	5A-40
C11	**21264	5A-38
C12	**21264	5A-38
C13	BB6-6	5A-54
C14	BB6-6	5A-51
C15	BB6-6	5A-48
C16	BB4-4	5A-47
C17	BB6-6	5A-52
C18	BB3-6	4A-51
C19	BB2-15	4A-12
C20	BB8-15	4A-13
C21	BB6-8	2A-20
C22	BB8-19	4A-65
C23	BB8-3	4A-65
C24	BB6-8	6A-12
C25	BB6-15	6A-15
C26	BB8-8	4A-21
F1	BS1-2	4A-17
G1	1791	3A-31
I1	BF1-10	2A-13
I2	BF1-9	4A-6
J1	*1773-1	2A-23
J2	BM2-9	4A-16
J3	19364-1	2A-7
K1	BJ1-5	4A-46
L1	BC1-8	5A-3
L2	BC1-8	5A-25
Q1	BL4-1	4A-1
Q2	BL4-14	5A-18
Q3	BL4-14	5A-21
Q4	BL4-1	5A-23
Q5	BL4-1	5A-2
Q6	BL4-11	4A-56
R1	*1773-1	2A-23
R2	*1773-1	2A-23
R3	*1773-1	2A-23
R4	*1773-1	2A-23

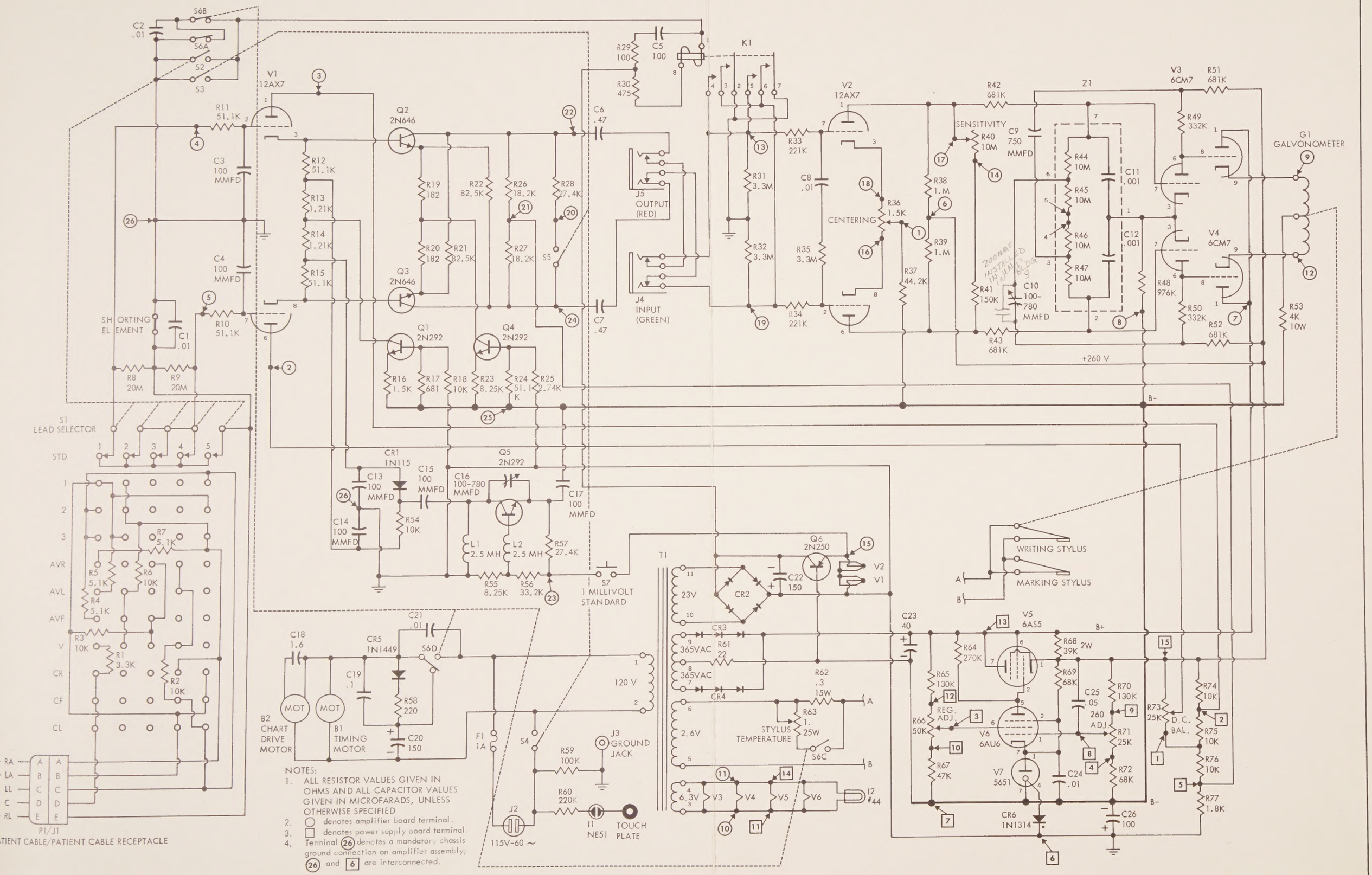
SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
R5	*17734	2A-23
R6	*1773-1	2A-23
R7	*1773-1	2A-23
R8	*1773-1	2A-23
R9	*1773-1	2A-23
R10	BI2-22	5A-43
R11	BI2-22	5A-45
R12	BI2-22	5A-20
R13	BI2-18	4A-1
R14	BI2-18	4A-1
R15	BI2-22	5A-26
R16	BI2-4	4A-1
R17	BI2-6	4A-1
R18	BI2-23	4A-1
R19	BI2-28	5A-17
R20	BI2-28	5A-27
R21	BI2-29	5A-30
R22	BI2-29	5A-29
R23	BI2-20	5A-22
R24	BI2-22	5A-24
R25	BI2-9	5A-53
R26	BI2-11	5A-32
R27	BI2-11	5A-19
R28	BI2-19	5A-46
R29	BI3-3	4A-65
R30	BI3-2	4A-65
R31	BI2-10	4A-63
R32	BI2-10	4A-63
R33	BI2-15	5A-36
R34	BI2-15	5A-15
R35	BI2-10	5A-16
R36	BB7-36	2A-19
R37	BI2-30	5A-1
R38	BI2-12	5A-41
R39	BI2-12	5A-34
R40	BB7-14	2A-18
R41	BI2-17	5A-13
R42	BI2-7	5A-35
R43	BI2-7	5A-39
R44	**21264	5A-38
R45	**21264	5A-38
R46	**21264	5A-38
R47	**21264	5A-38
R48	BI2-13	5A-10
R49	BI2-14	5A-37
R50	BI2-14	5A-8
R51	BI2-7	5A-7
R52	BI2-7	5A-6

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
R53	BI5-2	4A-23
R54	BI2-23	5A-49
R55	BI2-20	5A-4
R56	BI2-2	5A-31
R57	BI2-19	5A-28
R58	BI1-38	4A-13
R59	BI1-69	2A-12
R60	BI1-80	2A-14
R61	BI1-90	4A-22
R62	BI5-1	4A-28
R63	BB7-13	2A-17
R64	BI1-86	6A-17
R65	BI1-83	6A-9
R66	BB7-18	4A-32
R67	BI1-85	6A-2
R68	BI1-64	6A-8
R69	BI1-88	6A-10
R70	BI1-83	6A-16
R71	BB7-17	4A-33
R72	BI1-88	6A-13
R73	BB7-17	4A-33
R74	BI3-4	3A-7
R75	BI3-4	6A-11
R76	BI1-113	6A-5
R77	BI1-67	6A-4
S1	1773-1	2A-23
S2	*1773-1	2A-23
S3	*1894	2A-11
S4	*1894	2A-11
S5	*1894	2A-11
S6	BK4-7	2A-21
S7	BK4-8	2A-1
T1	20771-1	4A-19
V1	BL1-40	5A-5
V2	BL1-40	5A-14
V3	BL1-39	5A-12
V4	BL1-39	5A-11
V5	BL1-38	6A-1
V6	BL1-37	6A-3
V7	BL1-36	6A-6
CR1	BL4-15	5A-50
CR2	BL2-4	4A-53
CR3	BL2-1	4A-25
CR4	BL2-1	4A-25
CR5	BL4-6	4A-13
CR6	BL4-4	6A-14
Z1	21264	5A-38

* Designates switch assembly part number.
** Designates printed network.

NOTES:

1 Power supply tube 5651(V7) should not be removed from socket when power is on.



NOTES:
1. ALL RESISTOR VALUES GIVEN IN OHMS AND ALL CAPACITOR VALUES GIVEN IN MICROFARADS, UNLESS OTHERWISE SPECIFIED
2. ○ denotes amplifier board terminal.
3. □ denotes power supply board terminal.
4. Terminal (26) denotes a mandatory chassis ground connection on amplifier assembly; (26) and [6] are interconnected.

Figure 7A. Schematic Wiring Diagram - 300R

CATALOG 12

THE BIRTCHER CORPORATION • LOS ANGELES 32, CALIFORNIA

501-D38 500 2-65 RBP PRINTED IN U.S.A.